# GUIDELINES for SOIL & WATER MANAGEMENT SYSTEMS IN URBAN AREAS OF INDIANA

U. S. DEPARTMENT OF AGRICULTURE
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# GUIDELINES

# FOR

# SOIL AND WATER MANAGEMENT SYSTEMS

# IN URBAN AREAS

# OF INDIANA



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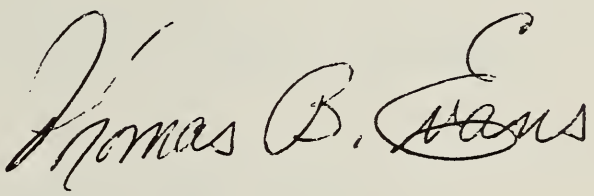
# FOREWORD

The Soil Conservation Service is concerned with the soil, water, and related resources aspects of resource plans developed and implemented by units of government. The rapid urbanization taking place in Indiana today makes this concern of utmost importance.

In working with Soil and Water Conservation Districts and local units of government, SCS assistance to date has consisted primarily of inventories and evaluations of soil, water, and related resources. However, assistance can and often does go beyond this type of help. Once the decision has been made to develop a given area, the planning and application of an adequate Soil and Water Management System is of prime importance and concern to us.

These guidelines are intended to provide Indiana SCS personnel additional guidance in assisting urban and urbanizing areas. This document should always be used in conjunction with the SCS Resource Conservation Planning Handbook, applicable Work Unit Technical Guide and Conservation Planning Memorandum 12 and Administrator's General Memorandum-6.

As we gain additional experience in this type of assistance, the contents of these guidelines will be refined, supplemented, and incorporated into Work Unit Technical Guides.



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State Conservationist

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## 100 INTRODUCTION

### 110 PURPOSE

The purpose of these guidelines is to provide Soil Conservation Service personnel with guidelines for use in assisting units of government, developers and others in planning and applying needed Soil and Water Management Systems to developing areas.[1] These guidelines are intended to supplement the SCS Resource Conservation Planning Handbook and the Work Unit Technical Guide by discussing Soil and Water Management Systems applicable to developing areas in Indiana. For policy and procedures regarding SCS assistance to urbanizing areas refer to the SCS Resource Conservation Planning Handbook, Conservation Planning Memo 12, and Administrator's General Memo-6. For standards and specifications of practices refer to the Work Unit Technical Guide.

### 120 NEED FOR SOIL AND WATER MANAGEMENT SYSTEMS

The urbanizing process is such that many people can be adversely affected from small areas of land undergoing development. Uncontrolled erosion, sedimentation, surface runoff and internal wetness of soils from these areas can cause economic and environmental damages to individuals and the community in general. An inadequate Soil and Water Management System can cause economic hardships on future homeowners. Improper planning can also result in flooding of homes, public facilities, industrial sites, etc., in the lower portions of drainage areas downstream from a developing area.

Hazards associated with urbanizing areas in Indiana include:

- An increase in the areas of soil exposed without adequate vegetative protection.
- Increased volumes of runoff, soil movement, sediment, and peak flows caused by removal of vegetative cover.
- An increase of impervious surface areas due to streets, buildings, parking areas, etc., caused by heavy equipment compaction.
- Altering the ground water regime that may adversely affect drainage systems and slope stability.

[1] Soil and Water Management System - A system of development which takes into full consideration soil limitations, erosion control, sedimentation, flooding, surface water removal, surface water storage, subsurface drainage, natural features, topography, and existing vegetation of the area.

- Exposing of subsurface materials that are unfavorable for revegetation.

- Obstruction of stream and natural drainageway flow by streets, buildings and land grading.

- Alteration of existing subsurface drainage by the overall development process.

- Overloading of existing surface and subsurface drainage due to increased volumes and rates of runoff.

- Poor timing of construction as related to anticipated weather conditions and proper sequence of construction.

## 200 RESOURCE CONSERVATION PLANNING

### 210 GENERAL

Effective solutions to soil and water management problems begin with planning. Broad resource plans, conservation plans, and inventory and evaluation data can guide policy and decision makers in such a manner as to achieve high quality developments with full consideration of the existing soil, water and related resources.

The Soil Conservation Service must provide, through Soil and Water Conservation Districts, soil, water, and related resource data and the necessary technical expertise that will lead to proper use and treatment of the area being considered for development. At the same time, the objectives of policy and decision makers must also be satisfied. These objectives may include reserving the best agricultural areas for cropland, designating areas of residential and industrial growth, open space and recreation areas, transportation systems, community facilities, etc.

In order for SCS assistance through SWCDs to be effective, the following conditions should exist:

- Soil and Water Management needs in urbanizing areas should become a stated policy of units of government (including the SWCD's Long Range Plan). Concerned public agencies should cooperate in program development and implementation within the realm of their resources and authorities.

- A public information and education program should be used to obtain public and industry support for a Soil and Water Management Program.

- Soil and Water Management provisions should be incorporated in the planning stage for most effective application in the construction stage of development.

- Practical combinations of technical principles must be available to plan and apply effective Soil and Water Management Systems.

- Competent technical personnel and workable procedures with enforced regulations are essential for a successful program.

220 DEVELOPMENT OF SPECIFIC SITE PLANS

As more specific plans, such as subdivision plans, are developed, SCS should furnish more detailed information and interpretations. This assistance will help to determine suitability of a site for the proposed development. SCS assistance should also relate to the design of the development and treatment of the area in such a way as to achieve an adequate Soil and Water Management System.

Basic data must be assembled before adequate SCS technical assistance can be provided for a specific site plan, such as a subdivision.

This data consists primarily of:

- Condition and Status of the Resources to be Developed

  Conditions of proposed project areas need to be examined early in the planning process. These conditions include location, accessibility, present land use, size of tract, topography, drainage pattern, geology, hydrology, soils, vegetation and climate. Such information is usually obtained from existing technical reports, maps records and documented material available from local sources.

- Knowledge of the Soils Present

  Soils information, interpretations and data are basic to any urban development. A good understanding of the soil resource provides an understanding of the limitations of the site for development. From this knowledge determinations can be made as to feasibility of the planned land use and the soil and water management requirements of the site.

230 NECESSARY ITEMS BEFORE SWCDs GIVE ASSISTANCE TO PLANNING COMMISSIONS IN DEVELOPING SUBDIVISION ORDINANCES ARE:

(1) The SCS, SWCD Supervisors, Planning Commission and local officials must recognize the need for SWCD assistance based upon obvious problems which the SWCD can point out and the local officials can agree upon. This involves both the SCS and District being personally "sold" on the use of technical soil and water conservation information and interpretation in urbanizing areas.

(2) The SWCD Supervisors should develop land use alternatives for the soils in their district and standards for adequate soil and water management systems. They can do this by adopting the Work Unit Technical Guide as their official standard or by developing their own.

Ordinarily it will be easiest for the Supervisors to adopt the standards established in Section III of the Work Unit Technical Guide. The Work Unit Technical Guide should be carefully reviewed and correct before SWCDs are encouraged to adopt it as their official standard. Important items to check are:

- Is the soils information in Section II complete?

- Are the standards for determining the adequacy of soil and water management systems clearly shown in Section III?

- Carefully check each practice in Section IV which has possibilities for urban application for changes needed to make the practice applicable to all land uses.

This kind of documentation is necessary in order to provide a firm basis for the development of ordinances and the technical review of subdivision plats.

(3) Develop memorandum of understanding between SWCD and Planning Commission. Before SWCDs attempt to assist Planning Commissions in developing subdivision ordinances an adequate memorandum of understanding should be developed between the SWCD and the Planning Commission clearly spelling out the assistance each will provide the other and what will be jointly undertaken. See Appendix for example.

SWCDs are primarily concerned with land use planning as it relates to use and treatment of land based upon soil characteristics.

Planning Commissions are primarily concerned with land use planning as it relates to location planning within the total community.

Working relations between SWCDs and Planning Commissions should strive to meet the primary concerns of both organizations.

(4) Develop the actual procedure for review of subdivison plats between the SWCD and the Planning Commission. (The fact that this will be done should be spelled out in the memorandum of understanding.) This should be a well defined procedure whereby at the preliminary plat stage, copies of all proposals are submitted to the SWCD by the Planning Commission for review and comment back to the Planning Commission within 20 days or less. NOTE: It is a must that the review procedure be well understood before revision or development of a subdivision ordinance is completed. It is also advisable for the actual procedure for review to be spelled out in the subdivision ordinance.

Burns Indiana Statute 53-746,748 gives two minimum steps for counties and cities to use in developing subdivision control ordinances. These are:

First - The developer desiring the approval of a plat shall submit a written application for a certificate, together with a copy of the proposed plat to the Planning Commission (Preliminary Plat Stage).

Second - The Planning Commission upon receipt of the application for approval of the plat, if it is approved, sets a hearing date, notifies the applicant in writing, and notifies by general publication, or otherwise, any person or governmental unit having a probable interest in the proposed plat.

If after the hearing by the Commission, it is determined that the application and plat comply with the standards set forth in the subdivision control ordinance, the Commission shall approve the plat.

In most instances, developers and Plan Commissions have found it advisable to have a "preapplication conference" before the preliminary plat is submitted. This is also the time when SWCD-SCS assistance can be the most effective in working with the developer. If the requirements for the subdivision plat are properly spelled out in the ordinance, the developer will soon learn the importance of contacting SWCD-SCS early in development.

## 240 ASSISTANCE BY SWCDs IN DEVELOPING SUBDIVISION ORDINANCES

SWCDs can be involved in many ways depending upon the method the Plan Commission chooses to use. A committee method is very workable whereby the SWCD is represented on the committee and furnishes information to the committee. There is no such thing as a "model" ordinance to fit Indiana problems and conditions. Ordinances must be tailored to fit local needs and desires.

The following soil and water management principles must be considered when developing subdivision ordinances:

- Soils with severe limitations (or very severe) for septic tanks and soil absorption fields as determined by a Soil Survey by USDA-Soil Conservation Service in cooperation with Purdue University Agriculture Experimental Station shall not be used for development unless a central sewage system is available (See Indiana State Board of Health S.E. 8).

- Soils in a floodway of a watercourse shall not be used for residential development unless adequately protected from flooding.

- The smallest practical area of land should be exposed at any one time during development.

- When land is exposed during development, the exposure should be kept to the shortest practical period of time.

- Temporary vegetation and/or mulching should be used to protect critical areas exposed during development.

- Sediment basins should be installed and maintained to remove sediment from runoff waters and land undergoing development.

- The permanent final vegetation and structures should be installed as soon as practical in the development.

- It is possible to effectively lower <u>seasonally</u> high water tables by the use of tile drains and open channels.

- No construction excavation, deposit or fill shall adversely affect the floodway of a watercourse.

240 Continued

- Ponded or excess water can be removed through grassed waterways and surface drainage channels.

- Surface runoff can be retained in detention reservoirs and metered into natural or artificial drains to reduce flooding.

- The development plan should be fitted to the topography and soils so as to create the least possible erosion and/or wetness potential.

- Natural vegetation should be retained and protected as nearly as possible.

- Top soil should be stockpiled and spread over areas that will otherwise be critical to establish in vegetation because of soil conditions.

250 EXAMPLES OF APPLICABLE STATEMENTS IN SUBDIVISION ORDINANCES

(Note: The following examples are excerpts from many different existing ordinances and are listed here to show various ways soil, water and related resource data can be used in ordinances. These examples should not be used as models without the benefit of the entire ordinance which gives authorities, variances, penalties, etc.)

"The subdivider shall submit a written application together with three copies of the proposed subdivision plan not less than ____days prior to the next regular hearing of the Planning Commission. One copy of the proposed subdivision plan is to be submitted by the Planning Commission to the _____County Soil and Water Conservation District for their review and comments not less than ___days prior to the hearing with the Commission."

"All preliminary plat plans shall include provisions for a soil and water management system which will take into account, erosion, sedimentation, surface drainage and internal drainage."

"The preliminary plat shall include a soil and water management plan to adequately stabilize soils on site, prevent off site damage to land, prevent pollution of streams and lakes and provide adequate surface and subsurface drainage."

250 Continued

"The preliminary plat shall include a soils map with interpretations showing limitations for the proposed land use."

"No land shall be subdivided for residential use if such land is considered by the Commission, based upon recommendations of the _____Department of Natural Resources and the _____County Soil and Water Conservation District to be unsuitable for such use by reason of flooding, improper drainage, objectional earth and rock formations, topography or any other soil limitation or feature harmful to the health and safety of future residents of the area as a whole."

"The street system layout shall be so designed insofar as practical to preserve natural features such as trees, streams, scenic views and to conform with the general topography of the area."

"Land to be subdivided shall be designed and improved in reasonable continuity to existing topography, in order to minimize grading, cut and fill and retain, insofar as possible, the natural contours, minimize storm water runoff and conserve the soil and natural cover."

"The design, installation and maintenance of erosion and sediment control measures shall be accomplished in accordance with the recommendations of the _____Soil and Water Conservation District as to adequacy for Soil and Water Management of the area."

"Adequate controls of erosion and sedimentation, both of a temporary and permanent nature shall be provided during all phases of development. These controls shall conform with the recommendations of the _____Soil and Water Conservation District."

"Soil Stabilization Plan - A plan to stabilize the area shall include shaping, grading, fertilization, seeding and mulching if disturbed areas are to be exposed and undeveloped during the period of November 1 to April 1. A plan to completely stabilize the area with permanent vegetation upon completion."

"Sediment basins will be installed and maintained as recommended by the _____Soil and Water Conservation District."

250 Continued

"Measures used to control erosion and sediment shall as a minimum meet the standards and specifications of the County Soil and Water Conservation District.

"Stripping of vegetation, regrading, or other development shall be done in a way that will minimize erosion."

"Development plans shall keep cut-fill operations to a minimum and ensure conformity with topography so as to create the least erosion potential."

"Whenever feasible, natural vegetation shall be retained, protected and supplemented."

"The disturbed area and the duration of exposure shall be kept to a practical minimum."

"Disturbed soils shall be stabilized as quickly as practicable."

"Temporary vegetation and/or mulching shall be used to protect exposed critical areas during development."

"The permanent (Final) vegetation and structural erosion control measures shall be installed as soon as practical in the development."

"Sediment in the runoff water shall be trapped by the use of debris basins, sediment basins, silt traps, or similar measures until the disburbed area is stabilized."

"Cut and fill slopes shall not be steeper than 2:1 unless stabilized by a retaining wall or cribbing, except as approved by the Engineer when handled under special conditions."

"Adequate provisions shall be made to prevent surface water from damaging the cut face of excavations or the sloping surfaces of fills."

"Cut and fills shall not endanger adjoining property."

"Fill shall be placed and compacted so as to minimize sliding or erosion of the soil."

"Fills shall not encroach on natural water courses or constructed channels."

"Grading will not be done in such a way so as to divert water onto the property of another land owner without the expressed consent of the land owner and the Planning Commission."

250 Continued

"During grading operations, necessary measures for dust control will be exercised."

"Grading equipment will not be allowed to cross live streams except by means of bridges or culverts."

"Endorsements and approval by the appropriate Department of Health and the County Soil and Water Conservation District shall be required when onsite sewer and water facilities are to be utilized. Endorsement and approval by the County Soil and Water Conservation District shall be required for erosion and sediment control measures."

"The subdivider shall be responsible for providing positive control of surface water runoff, without damaging erosion of causing wetness within limits of the subdivision area. It shall be the responsibility of the subdivider to submit complete drainage plans as needed at the time of final plat submission and these complete surface and subsurface drainage plans shall be approved by the Commission when the Commission determines that said plans are adequate."

"All drainage facilities shall be designed to convey surface water in such a manner as to prevent detrimental erosion, overflow or ponding to the nearest practical storm drain, street or natural water course in accordance with the applicable design criteria."

"Consistant with the joint memorandum of understanding between the Planning Commission and SWCD technical recommendations in establishing vegetative measure will be furnished by the _____ SWCD upon request of the developer and/or his agent."

260 ALL SUBDIVISION ORDINANCES SHOULD INCLUDE

A method of Preliminary Plat Review for comment and recommendations by the SWCD.

Requirements for a soil survey and interpretations for the proposed use to be furnished by each applicant.

Requirements for a Soil and Water Management System which takes into consideration erosion control, sedimentation, surface water removal, subsurface drainage and surface storage.

Avoid the "trap" of listing very exacting technical details in the ordinance itself - such as pounds of fertilizer, amounts and kinds of seed. It is much better to include the general

principles and concepts needed and refer to the recommendations of the SWCD for specific details, Planning Commission Specifications, etc. Always leave it so it is possible to "fall back on technical principles - than use your head!" Remember, once adopted, ordinances are not easy to change.

If the ordinance is referenced for technical details to the current SWCD Technical Guide as adopted by the Planning Commission, then this should take the form of a written record of specifications for this purpose. These specifications should be available at the SWCD office and the Plan Commission Office and must be kept up to date.

NOTE: FOR THE BASIC POLICY AND PROCEDURES OF PROVIDING ASSISTANCE TO UNITS OF GOVERNMENT SEE SECTION 740, RESOURCE CONSERVATION PLANNING HANDBOOK AND CONSERVATION PLANNING MEMO 12, DATED 10-15-71.

270 SOILS DATA AND INTERPRETATIONS

Soil data is basic to planning the use and management of soil and water resources in areas of expanding industry and housing. In the classification and mapping of soils, soil characteristics are determined that have a direct relationship to land use. Such characteristics as seasonal wetness, depth to bedrock, soil permeability, slope and soil texture will not only influence kinds and intensity of agriculture, but will also influence types and feasibility of development.

The level of generalization of soils data required is determined by the intensity of planning desired. Small scale general soil maps, land resource maps and the older series of published soil surveys are available for most counties in Indiana. These maps can be interpreted for broad resource planning. Large scale, modern, soil maps can be used in site selection and detailed site planning.

Many interpretations can be made from soil maps that will be useful in planning and influence management of soil and water resources. Examples of these, and their source of reference are:

- Determination of soil loss -

SCS Technical Guide, Section III-G
1971. Estimating Rainfall-Erosion Soil Loss on Construction Sites and Similarly Exposed and Unvegetated Areas In Indiana.

SCS Technical Guide, Section III-B
1963. Universal Soil Loss Equation.

270 Continued

- Determination of surface run off and peak flow

  SCS National Engineering Handbook, Section 4
  SCS Engineering Field Manual for Conservation Practices

- Determination of drainage requirements

  Indiana Farm Drainage Guide
  Purdue University Agriculture Extension Service in Cooperation with SCS, USDA.

- Determination of irrigation requirements in establishing vegetation

  A guide for Designing Sprinkler Irrigation Systems in Indiana, Purdue University Agriculture Extension Service in Cooperation with SCS, USDA.

- Determination of placement of engineering structures (Highways, Ponds, Embankments, Waterways, Diversions, Foundations, Residential development, Commercial and Industrial Development)

  SCS, Indiana, Soil Interpretation Sheets, IN-226-A&B

- Determination of agronomic, tree and shrub practices

  SCS-Indiana Technical Notes, Woodland Technical Note-6, Planting Guide for Trees and Shrubs for Outdoor Living

  SCS Technical Guide, Section III-E-1. Section IV Woodland Suitability Groups for Indiana

  SCS, Indiana Soil Interpretation Sheets, IN-226-A.

- Determination of usefulness for sanitary facilities (Septic tank absorption fields, sewage lagoons, sanitary land fills)

  Soil Considerations in Planning Waste Disposal Sites in Indiana, SCS and others.

- Determination of usefulness for recreation (Cottages, Camp Sites, extensive play areas, intensive play areas, paths and trails, golf fairways)

  SCS, Indiana, Soil Interpretation Sheets, IN-226-A

Criteria used to develop the above interpretations are found in Soils Memorandum SCS-22, 30 (agronomic), 26 (woodland), 69 (recreation), and Guide for Interpreting Engineering Uses of Soils (engineering structures and sanitary facilities).

Soil interpretations listed in this section are not meant to be all inclusive. Many imaginative (additional) soil interpretations are possible in resource planning. Imaginative interpretations, that are based on soil characteristics, are encouraged.

Many methods are available to illustrate soil interpretations. One method that is commonly used is the preparation of overlays. Translucent material is placed over the large scale soil map and colored to show soils that have the same suitability or limitation. For example, soils that have a slight limitation can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red. A simple procedure when working with small scale general soil maps is to provide a circular "pie" for each soil association and divide it to illustrate the proportion of soils in the association with slight, moderate and severe limitations for a given use.

## 300 ENGINEERING PHASE - SOIL AND WATER MANAGEMENT SYSTEMS

### 310 GENERAL PRINCIPLES INVOLVED

Uncontrolled runoff and excess erosion often occurs in urban developments, especially during the construction stage. This erosion forms rills and gullies; washes out roads; scours cut and fill areas; fills road ditches, storm drains, and streams; and does other damage that is costly to the developer and damaging to land users and areas below.

The need for surface and subsurface water disposal is often overlooked in planning a development. In many cases the drainage problem is complicated by the grading plan which does not recognize the need for drainage. Natural drainageways are often blocked by man-made obstructions. These create standing water or restricted flows. Poor planning at this stage of development often causes undue hardship on future property owners.

Careful inclusion of proven conservation practices in the development plan can prevent or alleviate much of this damage and should be a part of every development plan. For practices involving a drainage area of one square mile or more plans and specifications for such work should be submitted for approval to the Indiana Natural Resources Commission prior to construction.

These practices will usually be a combination of vegetative and engineering practices to be used. A number of practice engineering guides are included at the end of this chapter. Similar engineering guides for other practices may be needed locally based on local experience. Additional guides will be developed and added to this section as the need arises.

### 320 APPLICABLE CONSERVATION PRACTICES

#### .10 LAND GRADING

Most urban developments will require some grading. The objectives of grading should be to (a) divert water away from buildings, (b) prevent standing water and soil saturation detrimental to structures and to lot users, (c) provide for disposal of water from lot, and (d) provide grades for safe and convenient access to and around buildings and lots for their use and maintenance.

With the size of modern equipment available, there is practically no limit to the amount of earth moving that can be done. The development plan, however, should be based upon the incorporation of building designs and street layouts that fit and utilize existing topography and desirable natural surroundings insofar as practical to avoid extreme slope modification. Grading should be done in accordance with a well prepared plan. The developer needs to provide sufficient surveys and soil and subsurface

foundation information to determine limitations that must be imposed on grading operations. The plan considerations include such items as: best side slopes for slope stability, effect on adjacent properties and drainage patterns, measures for drainage and water removal, source of material, placement of material and degree of compaction; topsoil being stockpiled in areas where it will not contribute to the erosion problem; and after grading is finished, topsoil being respread back on areas where vegetation will be grown.

.11 BENCHES AND BERMS

Benches and berms are constructed as flat areas and are usually built on sloping land. Their purpose is to provide a relatively flat construction site or to reduce the length and grade of a slope. Benches may be placed on the contour or near contour and made wide enough to accommodate a house and lot. When properly planned and installed, they can materially reduce the runoff and erosion hazards by slowing down the velocity of water and providing greater intake opportunity. Benches usually consist of part cut and part fill area. Son steep slopes, the fill areas may be prone to slip or slide when wet. Sliding potential may be reduced by careful planning for disposal of runoff water from the building and lot. Sloping the bench to drain toward the cut area, where the water from the buildings and lot surfaces will drain into strom sewers, will reduce the chance of the fill areas becoming saturated and unstable.

Berms are often used to break up vertical and horizontal distances on cut and fill slopes. These are planned wide enough to accommodate the construction equipment in use, usually a minimum of 10 feet. They may be on the contour or a slight grade to move water in a planned direction. The outside edge of the berm is higher so that runoff water will collect next to the toe of the cut slope rather than flowing on or over the fill portion. The flow area or gutter may be established to grass or paved or may be a buried pipe to collect and move water to the disposal area. Berms may outlet on grass or sod, or wooded areas on smooth, gentle slopes, or may require use of gutters, paved ditches or pipe to lower the water to stable areas below the berm without damage. These are applicable on road cut and fill slopes and other similar areas.

.12 DIVERSIONS

Diversions are constructed across sloping land either on approximately the contour or at a predetermined grade. If constructed with a combination channel and ridge, it is known as a diversion. It consists of a channel below the natural surface of land and has no ridge, it is called a diversion ditch.

Diversions intercept surface runoff before it gains sufficient volume and velocity to cause erosion. Water is collected and moved laterally along the diversion at non-erosive velocities to a stable outlet where it may be safely released.

Diversions constructed above a development can keep outside runoff water from entering the developed area and materially reduce the water handling problem. Constructed above cut or fill slopes, they intercept runoff and prevent water moving over the face of the cut and fills. They may be constructed across graded areas, above buildings and other facilities to serve the same purpose.

Diversions that are to remain as a permanent part of the development should have side slopes flat enough to permit establishing to grass and to facilitate mowing. Soils with high water tables or those that tend toward wetness, may require tile along the diversion channel to aid in establishing and maintaining desirable grass species, to keep the surface dry and to reduce potential for aquatic weed and insect growth.

.13 GRASSED WATERWAYS, SWALES OR OUTLETS

Grassed waterways, swales or outlets make use of natural or excavated channels to dispose of excess runoff water at non-erosive velocities. These may be used to dispose of water from diversions, berms, benches and other areas. They are designed from a given runoff frequency occurrence. Following grading, soil is prepared by disking, scarifying or other methods, fertilized, limed if necessary and seeded or sodded to adapted grasses.

Vegetation will work well in stabilizing the waterway on slopes where non-erosive velocities can be maintained. In cases where there may be prolonged flow in the channel,

such as that from spring flow or snowmelt, other measures will be needed since grass may not do well where water is on the area a long period of time. This can be handled by combining a vegetated channel with a means of handling low frequency and prolonged flow in a paved channel, buried pipe or tile. When paving is used, the bottom of the channel and a small portion of the side slope is designed to carry the prolonged and frequent-occurring flow. The remaining capacity to be handled by the vegetated portion is based on the runoff from larger, more infrequent occurring rains. The same results can be accomplished by designing a pipe to carry the low flows with the vegetated channel to carry the larger flows. The pipe or tile is buried to one side and below the depth of the bottom of the channel with suitable inlets for surface low flow. In areas that have a soil wetness problem, the pipe or tile may have an advantage over the paved bottom in that by using open joints, the pipe or tile will serve as an underground tile drain to lower the water table and promote more vigorous growth of grass in the channel.

In some situations the slopes may be so steep, the soil so erosive, the accessability for vegetative maintenance or the climatic conditions such that permanent grass is not possible. In these situations, it will be necessary to use paved waterways or buried storm drains.

In many situations grade stabilization structures may be needed to reduce velocities to that considered safe. These consist of pipe, concrete, rock, masonry, steel, aluminum or timber devices to reduce the channel grade and velocities to stable limits. Care should be taken to design structures to harmonize with the natural features and to provide safety features for children.

The waterway design should include all needed structures such as those for grade control, inlets for side drains and tile or buried pipe.

.14 DEBRIS OR SEDIMENT BASINS

Debris or sediment basins may be used to trap runoff waters and sediment from a development. The water is temporarily detained or slowed down; the major portion of the sediment is carried by water, and is retained in the basin while the water is automatically released. These usually consist of a dam or embankment, a pipe outlet and

an emergency spillway. They are usually situated in natural drainageways or in the low areas of the development. In some situations where an embankment is not feasible, a basin excavated below the earth surface may serve the same purpose. These structures may be temporary or permanent. Temporary ones serve only during the construction stage and are eliminated when vegetation is established and the area is stabilized. Permanent structures are so designed that they fit into the overall plan for permanent installation.

The size of the structure will depend upon the location, size of drainage area, soils and rainfall pattern. Sufficient space for sediment should be provided to store the expected sediment yield from the drainage area for the planned life of the structure or provisions made for periodic cleanout of sediment from the basin. Dams trapping sediment must be carefully located and designed because failure during a major flood could have consequences far greater than most sediment problems created by development construction.

State and local safety regulations regarding such structures need to be observed concerning design, warning signs and fencing.

.15 GRADE STABILIZATION STRUCTURES

Grade stabilization structures may be constructed from such materials as earth, pipe, concrete, masonry, steel, aluminum, wood, sod or a combination of these. Grade stabilization structures are used to safely convey water from one level to a lower level without damage, to reduce grade in a water course, to stabilize headcutting or water courses or to change the direction of flow of water.

Structures may consist of straight drop spillways, box inlet drop spillways, drop box culverts, chutes, pipe drop inlets or hood inlets. An earthen embankment is usually incorporated as a part of the structure. Criteria for design and details for construction are contained in SCS engineering handbooks. Design should fit the natural surroundings and provide for safety features.

.16 PONDS AND RETARDING STRUCTURES

Ponds and retarding structures are useful in many sites in a development.

Well designed ponds or lakes add to the aesthetics of the development and can add functional utility for the area

residents. In many cases, land not suitable for other uses, such as low wet areas, can be utilized for a pond site. Ponds may be of the impounding type, utilizing a dam of earth or other material, or they may consist of pools excavated below the ground surface with excavated material used to fill and level around the pool area..

For impoundment-type ponds, the size should be balanced with the drainage area. There needs to be enough drainage area to keep the pond full, but not enough excess to create problems in disposing of the excess runoff after the pond is full. Ponds must be equipped with a pipe, weir notch or chute and a principal spillway to take care of flow from springs, snowmelt, prolonged flow from rainfall and that from low intensity, frequently occurring rains. An emergency spillway needs to be provided to pass the runoff from large, less frequently occurring storms. In most situations the emergency spillway can be excavated in earth and protected with adapted grasses.

Retarding structures are of the impoundment-type and temporarily store runoff water and release it at rates where flooding does not occur below.

They may be designed as multi-purpose structures, incorporated both detention storage and permanent storage of water for use such as a fish pond. They may be located above the development to trap water before it enters the area or may be located within the development area. The principle of trapping runoff water and releasing it at a slower rate than it enters the structure may permit the use of smaller channels, culverts and storm drains below and may result in a considerable saving in installation costs.

Planning and design principles, techniques and criteria for ponds and retarding structures are contained in Section IV Work Unit Technical Guides. Safety features should always be included.

.17 DRAINAGE

Many soils which are naturally wet, or in need of drainage, can be identified by use of soils maps and soil use interpretation data.

Excessively wet soils can create foundation problems for buildings and roads, cause wet basements and excess pumping costs, create health hazards and offer poor conditions for growing lawns and shrubs.

Surface drainage can be expedited by grading the surface so that it has enough slope to permit surface water to move off freely. A minimum grade of 0.3 to 0.5 percent is desirable. Shallow surface ditches or swales can be used as collectors and planned and constructed to move water to stable outlets at non-erosive velocities. Ditches need to be shallow, with flat side slopes to facilitate mowing.

Outlet channels consist of the construction of designed channels for the disposal of storm runoff from diversions, grassed waterways (swales) benched areas and other structures. The design is based on the runoff from predicted storm levels and includes the vegetation or structural measures required to protect the channel from scouring and erosion.

Subsurface drainage may be needed to remove free water from the soil profile. This may be done by buried pipe of clay, concrete, metal, fiber or plastic; water moves from the soil into the pipe by means of perforations or open joints and is transported to stable outlets. In many soils a filter of gravel, sand or fiberglass may be required around the pipe to provide better drainage to prevent soil from moving into the pipe.

Adequate water disposal must have the hydraulic characteristics to accommodate the maximum expected flow of storm waters for a given watershed for a specific duration and intensity of rainfall. Design should (1) account for both off-site and on-site waters, including waters coming onto a given tract from upstream, (2) discharge this water into the natural drainageway, and (3) convey this water to a point where it will flow by gravity into a stream, water channel, or drainageway or where it can be connected into existing facilities of sufficient capacity to receive this water. Systems should be constructed in such a manner that they can be maintained at reasonable cost.

Determination of the size and capacity of an adequate drainage system should take into account the planned development in the watershed. The design should not adversely affect adjacent or neighboring properties.

Planning and design principles, techniques and criteria for drainage practices are contained in Section IV, Work Unit Technical Guides.

.18 STREAMBANK PROTECTION (Other than Vegetation)

The control of bank erosion in an urban area is often a problem in main stream channels. This control can be accomplished in various ways. Engineering methods commonly used include riprap, rock cribs, slope paving blocks, gabions, jetties, fencing piling, etc. The purpose of these measures is to install a barrier that will withstand the erosive forces exerted by flowing water or to create a bank roughness that will reduce the erosive power by dissipating energy of the water as it moves along the bank line.

.19 STREAM CHANNEL CONSTRUCTION

It is often impractical to attempt control of an existing meandering channel. In this case, channel straightening realignment, or the construction of a new channel to designed cross-section and grade is necessary. In doing this, however, the danger exists of creating a new erosion cycle. The design must include conservation measures for the stabilization of the bed and banks of the proposed channel under the predicted runoff conclusion.

All channel work that is under the jurisdiction of local, county and state agencies should have prior approval of these agencies before construction.

.20 IRRIGATION

Irrigation is a useful tool in establishing temporary or permanent vegetation and can play an important part in controlling erosion. Grading operations are often completed when natural moisture is in short supply. Vegetation can often be established by wise application of irrigation water. An application following seeding operations, if needed, is usually from a tank truck or by portable sprinkler lines.

The quality of water used is important. Water with a high mineral or salt content should be avoided as it is harmful to plants and soil. Water should be applied at a rate determined by the intake rate of the soil. If water is applied faster than the soil can absorb it, runoff occurs and serious erosion problems can be created. This is especially true on steep slopes or on cut and fill slopes.

320 Continued

Frequent, light applications may be needed during the germination and early growth stage. Once the grass is well established, each watering should refill the root zone. Very seldom should less than an inch of water be applied.

Trees and shrubs have deep root systems and need a periodic deep soaking.

The amount of water to refill the root zone of soil can be determined from local irrigation guides. These guides and other information concerning irrigation are contained in SCS handbooks, standards and specifications.

.21 MISCELLANEOUS PRACTICES

There are other structural principles that should be observed during construction in order to make urban conservation practices more effective. These are:

- Sprinkle or apply dust suppressors. Keep dust down to a tolerable limit on construction sites and haul roads.

- Use temporary bridges or culverts where fording of streams is objectionable. Avoid borrow areas where pollution from this operation is inevitable.

- Protect streams from chemicals, fuel, lubricants, sewage or other pollutants.

- Avoid disposal of fill in floodplains or drainageways unless adequate means are developed to safety discharge normal or floodflows.

- Do not locate sanitary facilities over or adjacent to streams, wells, or springs.

- Locate storage and shop yards where erosion and sediment hazards are slight. Where this is not possible, apply necessary paving and erosion control practices.

330 ENGINEERING GUIDES - URBAN AREAS

330.1 LAND GRADING - URBAN AREAS

Definition

Reshaping the ground surface by grading to planned grades which are determined by engineering survey and layout.

Purpose

The practice is for one or more of the following: provide more suitable sites for buildings, facilities and other land uses; improve surface drainage; and control erosion.

Conditions Where Practice Applies

This practice is applicable where grading to planned elevations is practical for the purposes set forth above.

PLANNING

The grading plan and installation shall be based upon adequate surveys and investigations. The plan is to show the location, slope, cut, fill and finish elevation of the surfaces to be graded and the auxiliary practices for safe disposal of runoff water, slope stabilization, erosion control and drainage such as swales, waterways, lined ditches, diversions, grade stabilization structures, retaining walls and surface and subsurface drains.

The development and establishment of the plan shall include the following:

(1) The cut face of earth excavation which is to be vegetated shall not be steeper than 2 horizontal to 1 vertical. Cut slopes of materials not to be vegetated shall be at the safe angle of repose for the materials encountered.

(2) The permanent exposed faces of fills shall be no steeper than 2 horizontal to 1 vertical.

(3) Provisions are to be made to safely conduct surface water to storm drains or suitable natural water courses and to prevent surface runoff from damaging cut faces and fill slopes.

(4) Subsurface drainage is to be provided in areas having high water table, to intercept seepage that would affect slope stability, building foundations or create undesirable wetness.

(5) Excavations shall not be made so close to property lines as to endanger adjoining property without supporting and protecting such property from erosion, sliding, settling or cracking.

(6) No fill is to be placed where it will slide, or wash upon the premises of another or so placed adjacent to the bank of a channel as to create bank failure or reduce the natural capacity of the stream.

(7) Fills are to consist of material from cut areas, borrow pits or other approved sources.

## CONSTRUCTION

### General

Timber, logs, brush, rubbish and vegetable matter which will interfere with the grading operation or affect the planned stability of fill areas shall be removed and disposed of according to the plan.

Topsoil is to be stripped and stockpiled in amounts necessary to complete finish grading of all exposed areas requiring topsoil for the establishment of vegetation.

Fill material is to be free of brush, rubbish, rocks, logs, and stumps in amounts that will be detrimental to constructing stable fills.

Cut slopes which are to be topsoiled will be scarified to a minimum depth of 3 inches prior to placement of topsoil.

All fills intended to support buildings, structures, sewers and conduits are to be compacted to a minimum of 90 percent of standard proctor with proper moisture control. Compaction of other fills will be as required to reduce slipping, erosion or excess saturation.

Frozen materials or soft, mucky or easily compressible materials are not to be incorporated in fills intended to support buildings, parking lots, roads, structures, sewers or conduits.

Maximum thickness of layers of fills to be compacted are not to exceed 8 inches.

All areas are to be rough graded to within 0.2 foot of the planned elevation after allowance has been made for thickness of topsoil, paving or other installations.

All disturbed areas shall be left with a neat and finished appearance.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be mini-

mized. State and local laws concerning pollution abatement shall be complied with.

Protective Slopes Around Buildings

The protective slopes shall slope away from building foundations and water supply wells to lower areas or drainage swales or channels. The minimum horizontal length shall be 10 feet except where restricted by property lines. The minimum vertical fall of protective slopes shall be 6 inches, except that the vertical fall at the high point at the upper end of a swale may be reduced to 3 inches if a long slope toward a building or from a nearby high bank will not exist. Minimum gradients shall be 1/16 inch per foot (½ percent) for concrete or other impervious surfaces and ¼ inch per foot (2 percent) for pervious surfaces. Maximum gradient of protective slopes shall be 2½ inches per foot (21 percent) for a minimum of 4 feet away from all building walls except where restricted by property lines.

Other lot areas

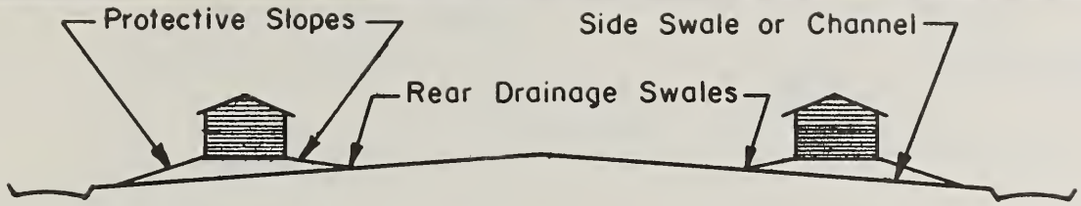
Each lot shall contain one or more areas having such location, size, and shape to adequately provide for outdoor living and for outdoor service functions such as laundry drying, temporary refuse collection, etc. Required usable lot area may be part of the protective slopes around buildings.

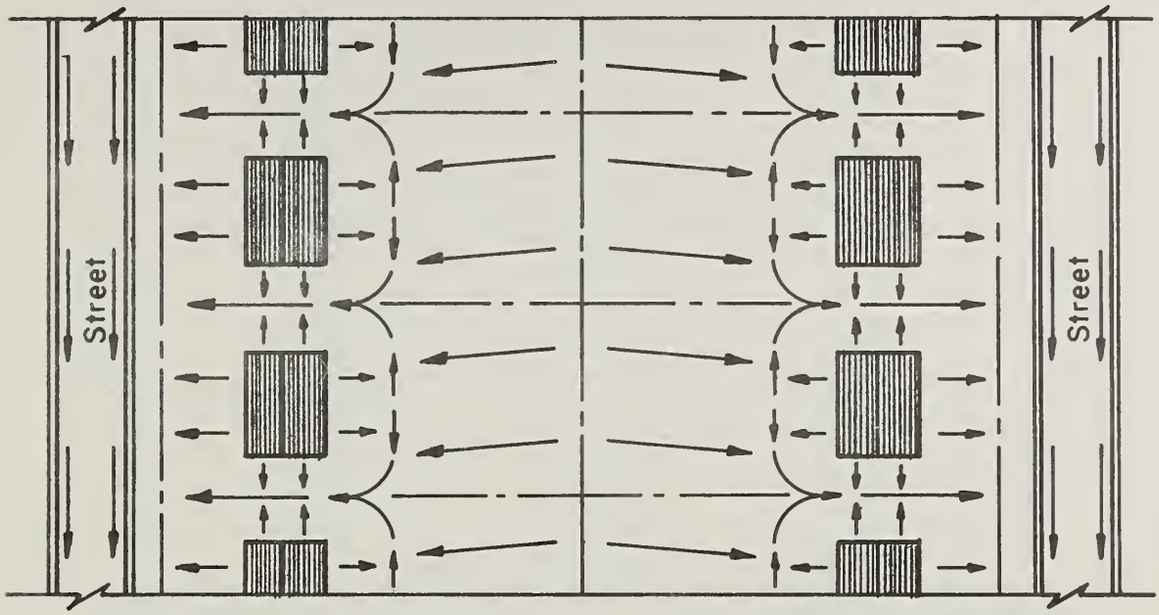
For concrete or other impervious surfaces, the minimum gradient shall be 1/16 inch per foot (½ percent). For pervious surfaces that are subject to ground frost, adverse moisture conditions, or detrimentally expansive soils, the minimum gradient shall be ¼ inch per foot (2 percent).

Maximum gradient for usable lot area is 5/8 inch per foot (5 percent). For other lot areas not classified as usable areas, the maximum slope shall be 2 feet horizontal to 1 foot vertical. There shall be no limit when a slope is satisfactorily held by existing vegetation or rock outcropping and when present and future stabilization is assured.

Tops and bottoms of banks at swales, terraces, etc., shall be rounded for convenient maintenance.

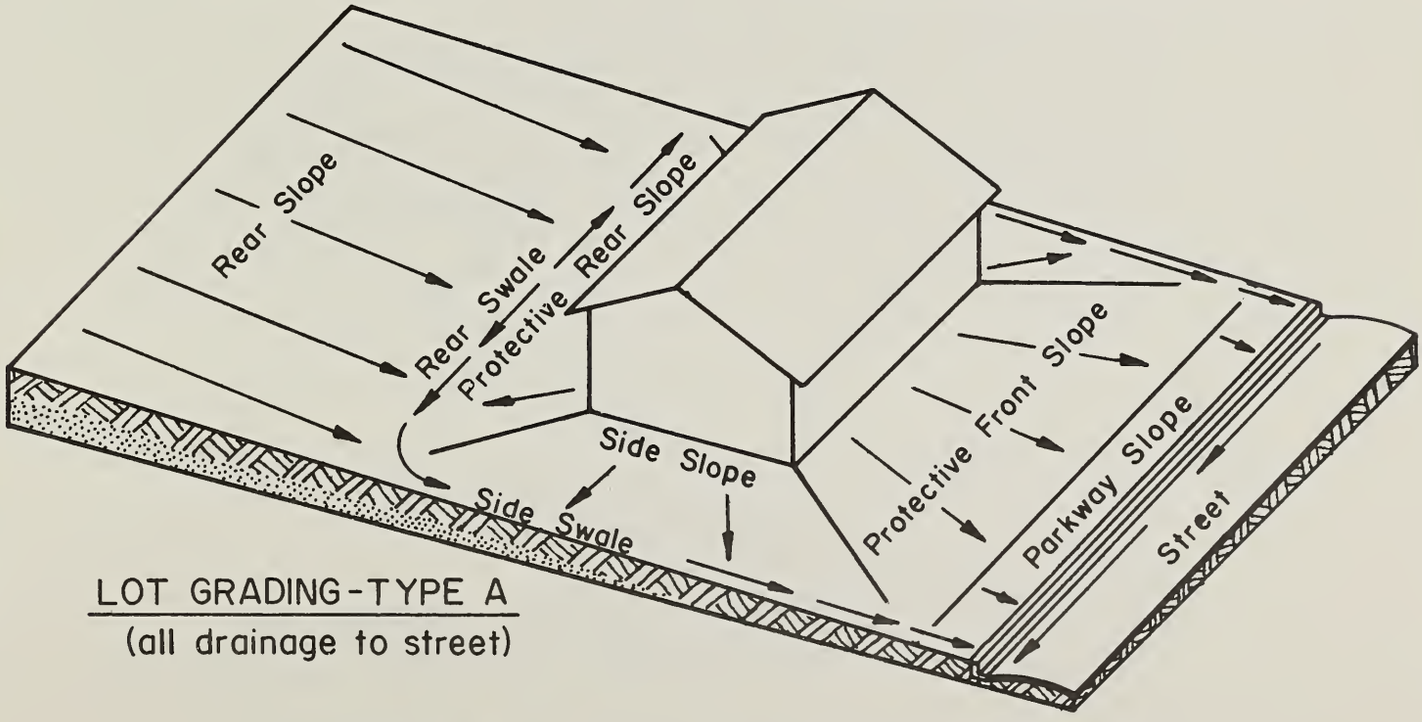
# LAND GRADING - URBAN AREAS




LOT GRADING - TYPE A

LOT GRADING - TYPE A




LOT GRADING - TYPE A
(all drainage to street)

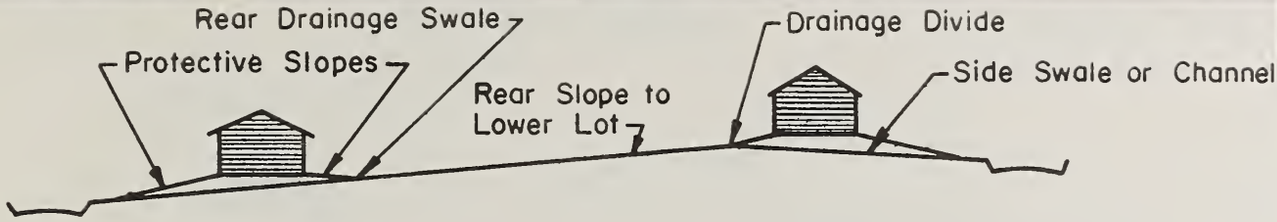
## EXAMPLE: BLOCK GRADING TYPE I

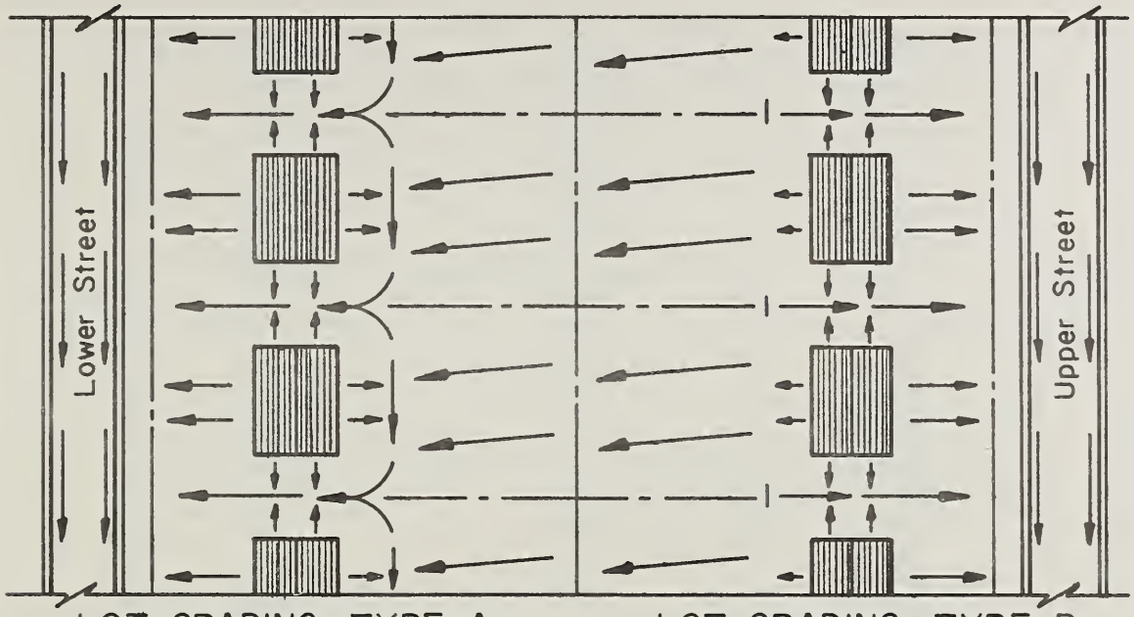
Ridge Along Rear Lot Lines

REFERENCE
"Minimum Property Standards for One and Two Living Units"
HUD-FHA
November 1966 FHA No. 300

US DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
INDIANA

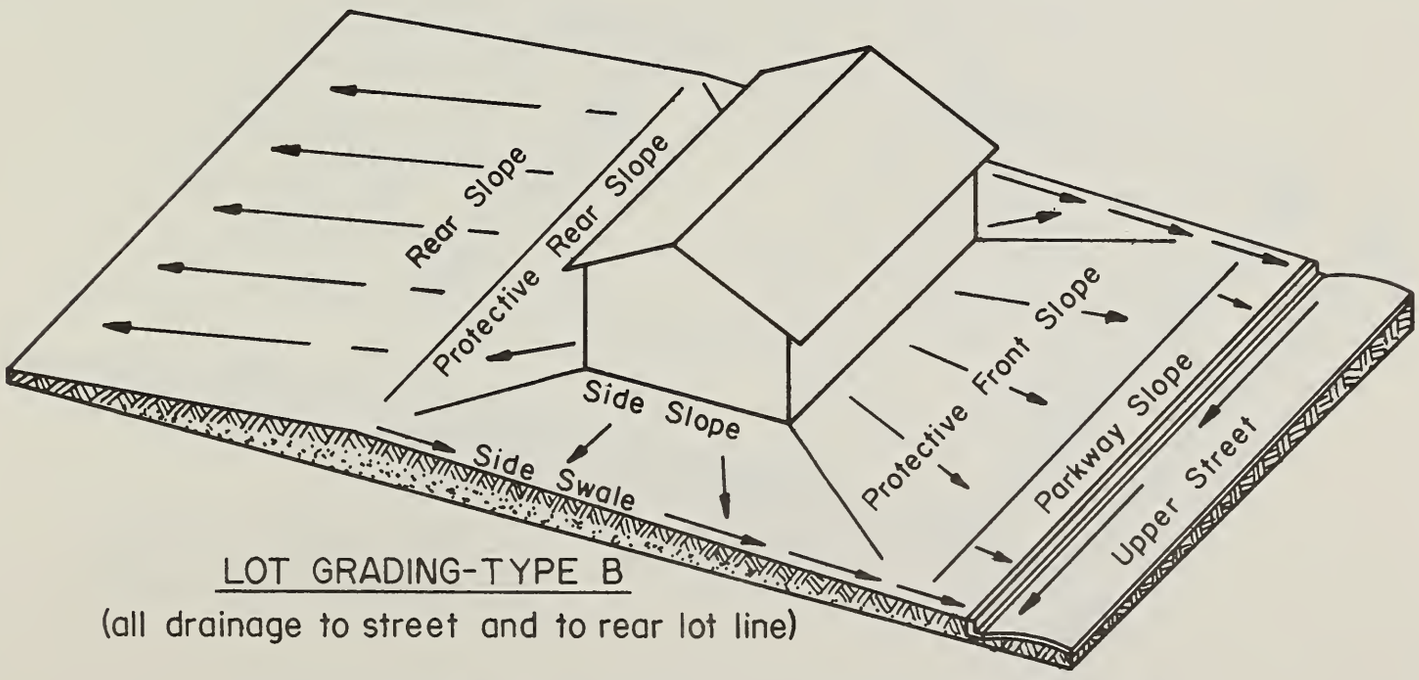
# LAND GRADING - URBAN AREAS




LOT GRADING - TYPE A

LOT GRADING - TYPE B




LOT GRADING - TYPE B

(all drainage to street and to rear lot line)

## EXAMPLE: BLOCK GRADING TYPE 2

Gentle Cross Slope

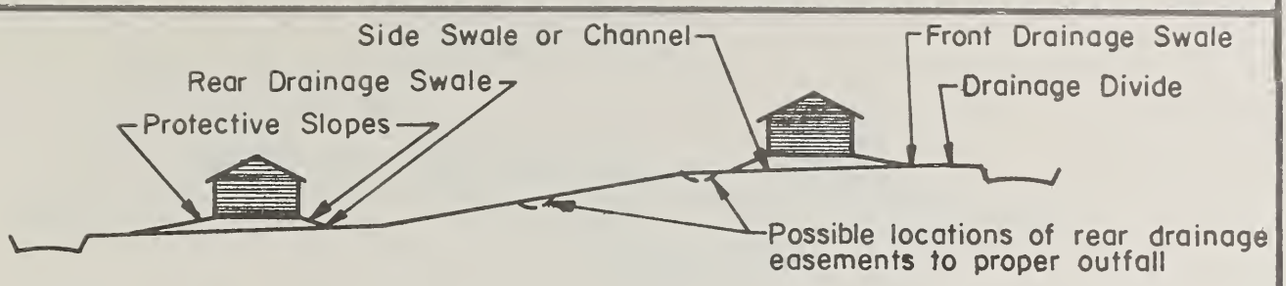
REFERENCE

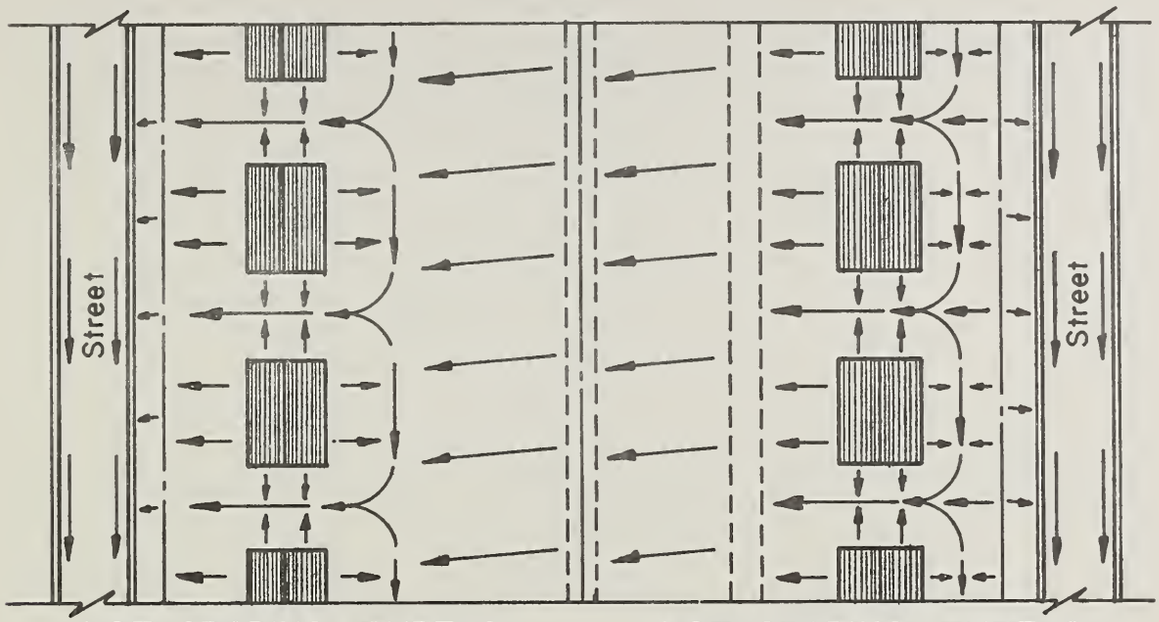
"Minimum Property Standards for One and Two Living Units" HUD-FHA

November 1966 FHA No. 300

US DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
INDIANA

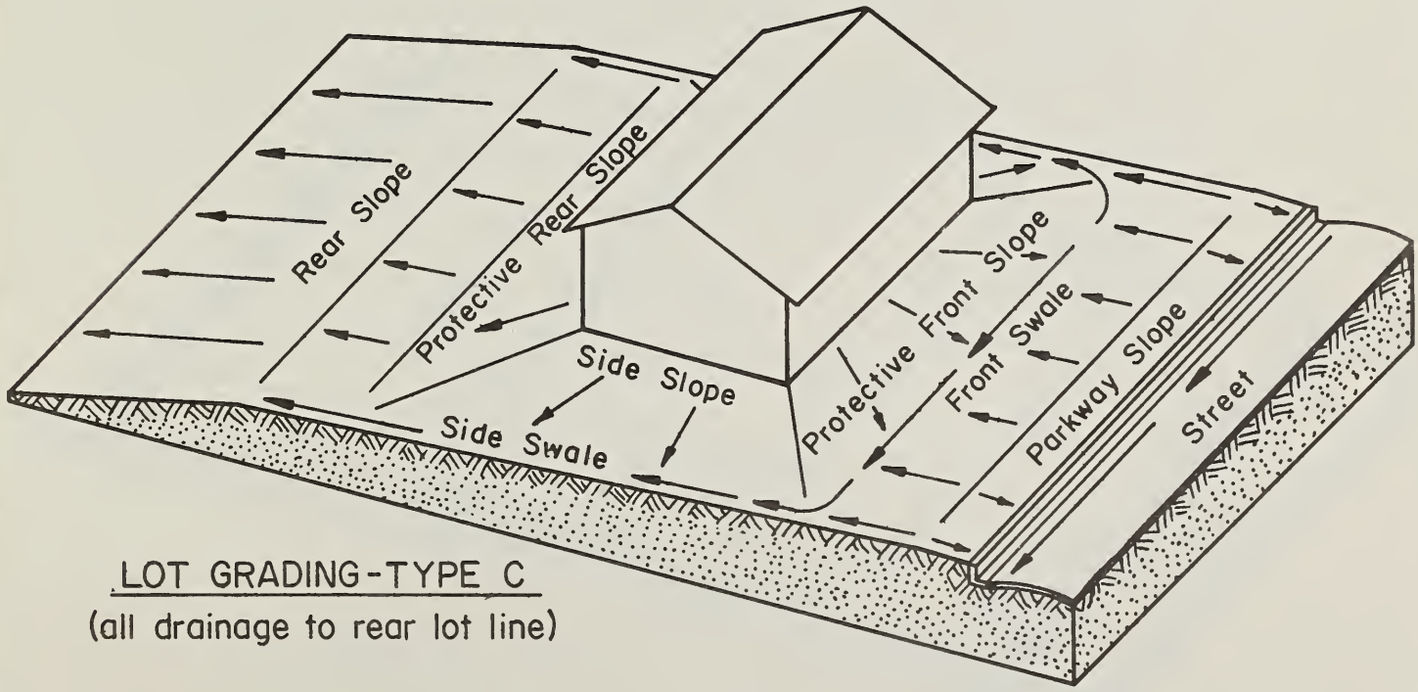
# LAND GRADING – URBAN AREAS




LOT GRADING - TYPE A

LOT GRADING - TYPE C



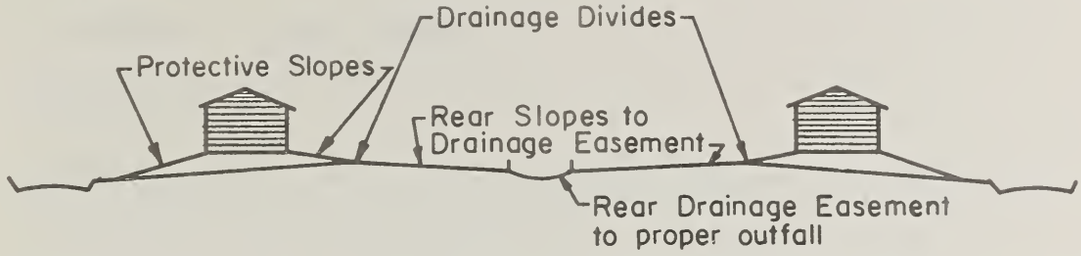

LOT GRADING - TYPE C
(all drainage to rear lot line)

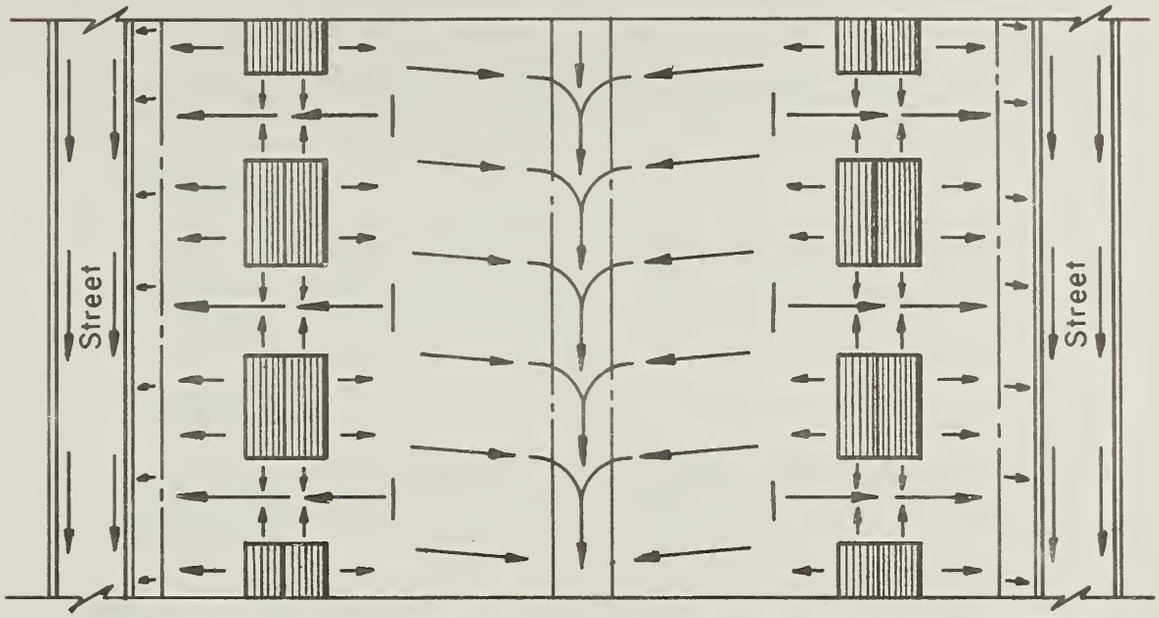
## EXAMPLE: BLOCK GRADING TYPE 3
Steep Cross-Slope

REFERENCE
"Minimum Property Standards for One and Two Living Units"
HUD-FHA
November 1966 FHA No. 300

US DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
INDIANA

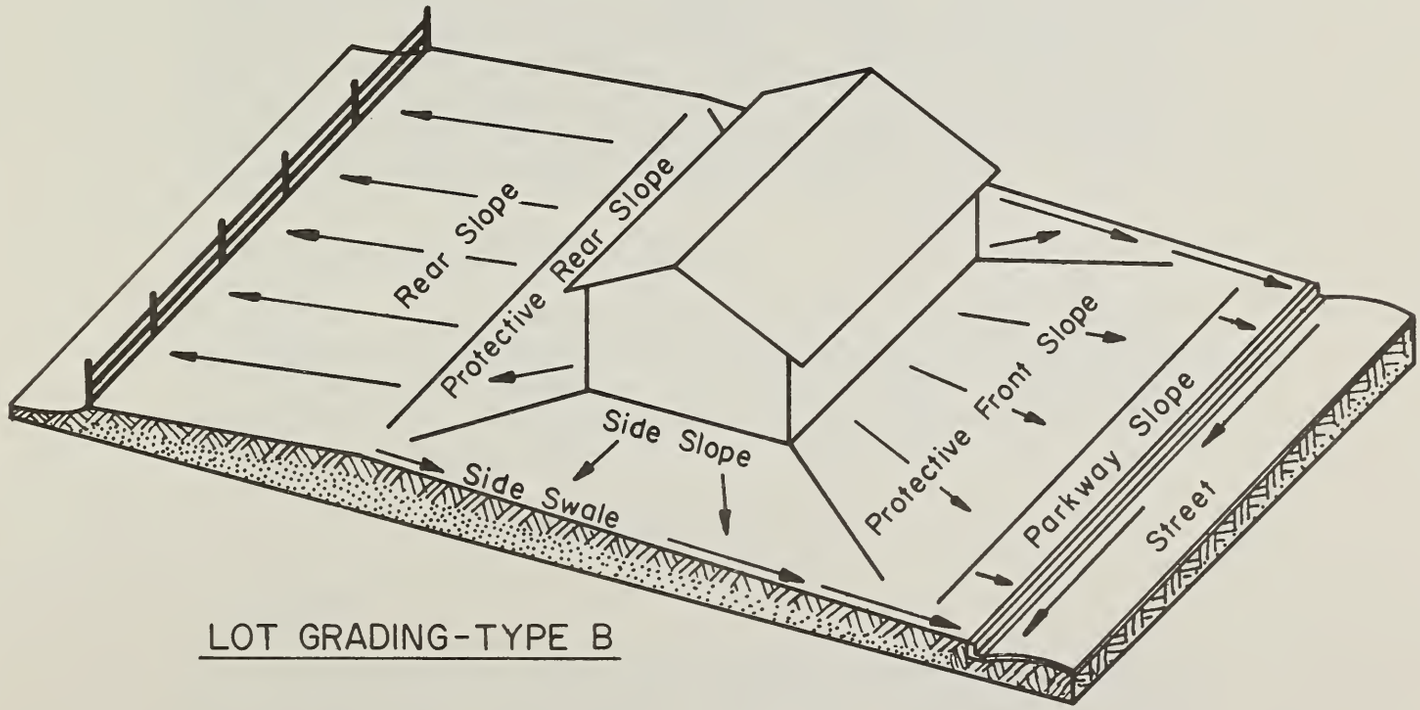
# LAND GRADING - URBAN AREAS




LOT GRADING - TYPE B

LOT GRADING - TYPE B




LOT GRADING - TYPE B

## EXAMPLE: BLOCK GRADING TYPE 4

Valley Along Rear Lot Lines

REFERENCE
"Minimum Property Standards for One and Two Living Units"
HUD-FHA
November 1966 FHA No. 300

US DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
INDIANA

## 330.2 DIVERSIONS - URBAN AREAS

### Definition

An earth channel with a supporting ridge on the lower side constructed across the slope.

### Scope

This standard applies to temporary and permanent diversions in urban developments. Diversions are classified as follows:

#### Temporary

Diversions installed as an interior measure to facilitate some phase of construction. They usually have a life expectancy of 1 year or less.

#### Permanent

Diversions installed as an integral part of an overall water disposal system and to remain for protection of property.

### Purpose

The purpose of this practice is to reduce slope lengths, break up concentration of runoff and move water to stable outlets at a non-erosive velocity. They may serve such purposes as diverting water from (1) lower lying areas, (2) cut or fill slopes or steeply sloping land, (3) construction sites, (4) buildings and residences, and (5) active gullies or other erodible areas.

### Site Evaluation for Feasibility

Diversions are to have stable outlets. The site, slopes and soils must be such that the diversion can be constructed and maintained throughout its planned life. Construction of diversions and outlets must be in compliance with state drainage and water laws.

## PLANNING

### Location

Diversion location shall be determined by considering outlet conditions, topography, land use, development layout, soil type and length of slope. Avoid locations in or immediately below unstable or highly erosive soils unless special treatment or stabilization measures are previously applied.

Capacity

Peak runoff values used in determining the capacity requirements shall be determined as outlined in Chapter 2, Estimating Runoff, "Engineering Field Manual for Conservation Practices," or by other accepted methods. The minimum design 24-hour storm frequencies and freeboard shall comply with the following table:

| Diversion Type | Typical Areas of Protection | Design Frequency | Freeboard Required |
|---|---|---|---|
| Temporary | Construction roads; land areas, etc. | 2 yrs. | 0.0 |
| | building sites | 5 yrs. | 0.0 |
| Permanent | Land areas, playfields, recreation areas, etc. | 25 yrs. | 0.3 ft. |
| | Homes, schools, industrial bldg., etc. | 50 yrs. | 0.5 ft. |

In all cases, the design storm frequency should be chosen to provide protection which is compatible with the hazard of damage that would occur if the diversion should overtop.

Design Velocities

Permissible design velocities should be determined by use of the following tables:

Selection of Vegetal Retardance

| Average Length of veg., inches | Retardance | |
|---|---|---|
| | Good Stand | Fair Stand |
| 11-24 | B | C |
| 6-10 | C | D |
| 2-6 | D | D |

Permissible Velocities

| Soil Texture | Permissible Velocity Ft./Sec. | | | | |
|---|---|---|---|---|---|
| | Bare Channel | Channel Vegetation | | | |
| | | Retardance | Poor | Fair | Good |
| Sand, silt, Sandy loam and Silty loam | 1.5 | B | 1.5 | 3.0 | 4.0 |
| | | C | | 2.5 | 3.5 |
| | | D | | 2.0 | 3.0 |
| Silty clay loam Sandy clay loam | 2.0 | B | 2.5 | 4.0 | 5.0 |
| | | C | | 3.5 | 4.5 |
| | | D | | 3.0 | 4.0 |
| Clay | 2.5 | B | 3.0 | 5.0 | 6.0 |
| | | C | | 4.5 | 5.5 |
| | | D | | 4.0 | 5.0 |

Cross Section

The channel may be parabolic, "V" shaped or trapezoidal. The diversion is to be designed to have stable side slopes. The side slopes for permanent diversions should not be steeper than 3:1 for maintenance purposes and preferably 4:1. The back slope of the ridge is not to be steeper than 2:1 and preferably 4:1. The ridge after settlement is to be 4.0 feet at the design water elevation. In determining the cross section on temporary diversions, consideration should be given to soil type and frequency and type of equipment that is anticipated to be crossing the diversion. In no case should side slopes be steeper than 1:1.

Outlets

Diversions are to have adequate outlets which will convey runoff without damaging erosion. The following types of outlets are acceptable:

- Natural or constructed vegetated outlets capable of safely carrying the design discharge. The outlet should be established and well vegetated prior to construction of the diversion.

- Properly designed and constructed grade stabilization structures or storm sewers.

- Open ditch channels which are stable and have adequate capacity and depth.

- A stable area having a good sod cover or a woodland area with a deep erosion resistant litter. When one of these two types of outlets is used, the outlet end of the diversion channel should be flared in a manner to spread the water over a wide area at a shallow depth.

Grade

Channel grade for diversions may be uniform or variable. The allowable velocity for the soil type and vegetative cover will determine maximum grade. Level diversions with blocked ends may be used provided pipes of sufficient size and spacing are placed in the embankment to drain the channel following cessation of runoff.

Protection Against Sediment

Temporary diversions - none required.

Permanent diversions - as a minimum, a filter strip of close growing grass or trees shall be maintained above the channel. The width of the filter, measured from the center of the channel, shall be one-half the channel width plus 15 feet.

The diversion ridge and channel are to be seeded to grass to prevent erosion.

Small eroded areas and sediment-producing channels draining into the diversion are to be shaped and seeded prior to or at the time the diversion is constructed.

CONSTRUCTION

All trees, brush, stumps and other objectionable material shall be removed so they will not interfere with construction or proper functioning of the diversion. All ditches or gullies which must be crossed will be filled and compacted prior to or as part of the construction. Fence rows and other obstructions that will interfere with construction or the successful operation of the diversion are to be removed.

The base for the diversion ridge is to be prepared so that a good bond is obtained between the original ground and the placed fill. Vegetation is to be removed and the base thoroughly disked before placement of fill.

The minimum constructed cross section is to meet the design requirements. The top of the constructed ridge is not to be lower than the design elevation plus the specified amount for settlement.

Fertilizing, seeding and mulching shall conform to the recommendations in the SCS technical guide.

If there is no sediment protection provided on temporary diversions, it should be anticipated that periodic cleanout may be required.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized. State and local laws concerning pollution abatement shall be complied with.

## 330.3 GRASSED WATERWAYS, SWALES OR OUTLETS - URBAN AREAS

### Definition

A natural or constructed waterway or outlet shaped or graded and established in suitable vegetation as needed for safe disposal of runoff water.

### Purpose

To dispose of excess surface water from urban areas without damage from erosion or flooding.

### Conditions Where Practice Applies

This practice applies to sites where added capacity or vegetative protection or both are required to control resulting from concentrated runoff.

Supplemental measures may be required with this practice. These may include such things as (1) grade control structures, (2) subsurface drainage to permit growing suitable vegetation and to eliminate wet spots that may be a public nuisance, and (3) a paved channel bottom or buried storm drain to handle frequently occurring storm runoff, base flow or snowmelt.

### PLANNING

### Compliance with Laws and Regulations

Design and construction shall be in compliance with state and local laws and regulations. Such compliance is the responsibility of the landowner or developer.

Capacity

The minimum capacity is to be that required to convey the peak runoff expected from a 24-hour, 10-year frequency storm. Channel diversions may be determined from exhibits in Chapter 7 of SCS Engineering Field Manual using the appropriate retardance factor or by Manning's formula using a suitable "n" value.

Velocity

The design velocity is to be based upon soil, duration of flow and type and quantity of vegetation using the procedure in the Standard for Diversions. However, the maximum design velocity will be 4.0 feet per second for vegetation established by seeding and 6.0 feet per second for that established by sodding.

Cross Section

The cross section may be parabolic, "V" shaped or trapezoidal.

Width

The bottom width of trapezoidal waterways or outlets are not to exceed 50 feet unless multiple or divided waterways are used or other means provided to control meander of low flow.

Depth

The minimum depth of a waterway receiving water from diversions or tributary channels is to be that required to keep the design water surface in the waterway or outlet at or below the design water surface elevation in the diversion or other tributary channel at their junction. To provide for loss in channel capacity due to vegetal matter, accumulation, sedimentation and normal seedbed preparation, the channel depth and width should be increased proportionally to maintain the hydraulic properties of the waterway. In parabolic channels this may be accomplished by adding 0.3 foot to the depth and 2 feet to the top width of the channel. This is not required on waterways located in natural watercourses.

Where a paved bottom is used in combination with vegetated side slopes, the paved section is to be designed to handle the base flow, snowmelt or runoff from a one-year frequency storm, whichever is greater. The flow depth of the paved section shall be a minimum of 0.5 foot.

Drainage

In areas with high water table, seepage problems or prolonged low flows, tile drainage, lined pilot channel, stone centers or other subsurface drainage methods are to be provided. A minimum drainage coefficient of 3/8 inch in 24 hours is to be used for tile design. An open joint storm drain, lined pilot channel, may be used to serve the same purpose and also handle frequently occurring storm runoff, base flow, snowmelt, prolonged low flows. The storm drain should be designed to handle base flow, snowmelt or the runoff from a one-year frequency storm, whichever is greater.

## CONSTRUCTION

Trees, brush, stumps and other material in objectional amounts are to be disposed of so as not to interfere with construction or proper functioning.

The channel section is to be free of bank projections or other irregularities which prevent normal flow.

Earth removed and not needed in construction is to be spread or disposed of so as not to interfere with the functioning of the waterway.

Fills are to be compacted as needed to prevent unequal settlement that will cause damage in the completed waterway.

Vegetating

Waterways or outlets shall be protected against erosion by vegetative means as soon after construction as practical and before diversions or other channels are outletted into them. Consideration should be given to sodding of channel to provide erosion protection as soon after construction as possible.

Site Preparation, Seeding & Mulching

- Grade and smooth as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding and mulching.

- Install other needed erosion control practices such as berms, diversion or interceptor ditch to protect the area during establishment of vegetation.

- Fertilizer and lime shall be in accord with applicable standards.

- Prepare a good smooth seedbed. Incorporate fertilizers and lime in top two or three inches of soil. Firm with cultipacker before seeding.

- Select a suitable plant species. Apply seed uniformly with a cyclone seeder, drill cultipacker seeder or hydra-seeder. If hydra-seeder is used the slurry will contain the seed and fertilizer.

- All vegetative channels or outlets should be mulched. Refer to mulching specifications for permanent vegetative cover.

- Where feasible, temporary diversions or other erosion control practices should be used to dispose of runoff water during period of establishing vegetative cover.

- If soil moisture is deficient when planting, apply adequate water for seed germination and plant emergence. Continue to irrigate as needed until plants are well established and have provided adequate ground cover to protect the area.

- Inspect area for failures and make necessary repairs, replacements or re-seeding as necessary within planting season. If complete re-seeding is necessary, apply ½ the original recommended rate of fertilizer with full rate of seed.

- Mow weeds as needed or use recommended chemicals to suppress weeds. Clip growth to a minimum height of 4 or 5 inches.

## 330.4 DEBRIS OR SEDIMENT BASINS - URBAN AREAS

### Definition

A barrier or dam constructed across a waterway or at other suitable locations to form a basin for catching and storing sediment and other waterborne debris.

### Scope

This standard covers the installation of debris basins on sites where: (1) failure of the structure would not result in loss of life or interruption of use or service of public utilities (SCS hazard class A); (2) the drainage area does not exceed 200 acres; and (3) the water surface area at

the crest of the emergency spillway does not exceed 5 acres. For the purpose of this standard, debris basins are classified according to the following table:

| Class | Maximum Drainage Area (acres) | Maximum Height 1/ of Dam (ft.) | Emergency Spillway Required | Principal Spillway (24-hour storm AMC II) | Emergency Spillway (24-hour storm) 4/ | Top of Fill |
|---|---|---|---|---|---|---|
| 1 2/ | 20 | 5 | No | --- | --- | 1 foot freeboard above design flow in emergency spillway |
| 2 | 20 | 10 | Yes | Route Q 10 yrs 3/ | 1 cfs per acre of watershed | |
| 3 | 200 | 20 | Yes | Route Q 25 yrs 3/ | 0.5 $Q_{50}$ peak | |

1/ Height is measured from the low point in the natural stream bed along the centerline of dam to the top of dam for Class 1 and to crest of emergency spillway for Classes 2 and 3.

2/ Class 1 basins are to be used only where site conditions are such that it is impractical to construct an emergency spillway in undisturbed ground.

3/ Storage may be determined by short cut methods.

4/ Emergency spillway crest shall be set above the storage requirements of the principal spillway and not lower than the elevation at which the principal conduit flows full. Minimum design depth flow in the emergency spillway shall be six inches.

Purpose

To provide a permanent or temporary means of trapping and storing sediment from eroding areas in order to protect properties or stream channels below the installation from damage by excessive sedimentation and debris.

Conditions Where Practice Applies

Where physical conditions or land ownership preclude the treatment of the sediment source by the installation of erosion control measures to reduce runoff and erosion, it may also be used as a permanent or temporary measure during grading and development of areas above. If it is a temporary structure, it may be removed once the development is complete and the area is permanently protected against erosion by vegetative or mechanical means.

PLANNING

The capacity of the debris basin to the elevation of the crest of the principal spillway is to equal the volume of the expected sediment yield from the unprotected portions of the drainage area during the planned useful life of the structure. The minimum volume of sediment in acre-feet per year can be determined for various drainage areas under construction from the method in the Work Unit Technical Guide Section III-G. This method is based on the Universal Soil Loss Equation which can be used to estimate soil loss and sediment production from construction sites where subsoils and underlying materials are exposed and left unvegetated. The Universal Soil Loss Equation is designed to estimate soil losses by sheet erosion only. Construction sites are also subject to rill and gully erosion. The losses from gullying are in addition to losses from sheet erosion and, therefore, must be taken into account for determining total losses on a given site.

Spillway Design

Runoff will be computed by the method outlined in Chapter 2, Estimating Runoff "Engineering Field Manual for Conservation Practices" or other accepted methods. Runoff computations should be based upon the soil cover conditions expected to prevail during the construction period of the development.

For Class 2 basins, the combined capacities of the principal and emergency spillways will be sufficient to pass the peak rate of runoff from a 10-year frequency storm after adjustments for flood routing. (Method shown in SCS Engineering Field Manual may be used.)

For Class 3 basins, the combined capacities of the pipe and the emergency spillways will be sufficient to pass the peak rate of runoff from a 25-year frequency storm.

Pipe Spillways

The pipe spillway will consist of a vertical pipe or box-type riser jointed to a conduit which will extend through the embankment and outlet beyond the downstream toe of the fill. The minimum diameter of the conduit will be 8 inches. The riser will be perforated to provide for a gradual drawdown after each storm event. The minimum average capacity of the principal spillway will be sufficient to discharge 5 inches of runoff from the drainage area in 24 hours (0.21 cfs per acre of drainage area). The riser of the principal spillway shall be a cross-sectional area at least 1.3 times that of the barrel.

- Crest Elevation - The crest elevation of the riser shall be at least 3 feet below the crest elevation of the embankment.

- Perforated riser - Metal pipe risers shall be perforated with 1½ inches diameter holes spaced 8 inches vertically and 10-12 inches horizontally around the pipe. Box-type risers shall be ported or have some means for complete drainage of the sediment pool within a five day period following storm inflow.

- Anti-vortex device - An anti-vortex device shall be installed on the top of the riser.

- Base - The riser shall have a base attached with a watertight connection. The base shall have sufficient weight to prevent flotation of the riser.

- Trash rack - An approved trash rack shall be firmly attached to the top of the riser if the pipe spillway conveys 25 percent or more of the peak rate of runoff from the design storm.

- Anti-seep collars - Anti-seep collars shall be installed around the pipe conduit within the normal saturation zone when any of the following conditions exist:

    - The settled height of dam exceeds 10 feet.

    - The conduit is of smooth pipe larger than 8 inches in diameter.

    - The conduit is of corrugated metal pipe larger than 12 inches in diameter.

The anti-seep collars and their connections to the pipe shall be watertight. The maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe.

- Outlet protection - Protection against scour at the discharge end of the pipe spillway shall be provided. Protective measures may include structures of the impact basin type, rock riprap, paving, revetment, excavation of plunge pool or use of other approved methods.

Emergency Spillways

Class 2 and 3 - An emergency spillway shall be excavated in undisturbed ground wherever site conditions permit. The emergency spillway cross section shall be trapezoidal with a minimum bottom width of 8 feet.

Class 1 basins - The embankment may be used as an emergency spillway. In these cases, the downstream slope of the embankment shall be 5:1 or flatter and the embankment must be immediately protected against erosion by means such as sodding, rock riprap, asphalt coating or other approved methods.

- Capacity - The minimum capacity of the emergency spillway shall be that required to pass the peak rate of runoff from the design storm, less any reduction due to flow in the pipe spillway. Emergency spillway dimensions can be determined by using the method outlined in Chapter 11 of "Engineering Field Manual for Conservation Practices."

- Velocities - The maximum allowable velocity of flow in the exit channel shall be 6 feet per second for vegetated channels. For channels with erosion protection other than vegetation, velocities shall be in the safe range for the type of protection used.

- Erosion protection - Provide for erosion protection by vegetation or by other suitable means such as rock riprap, asphalt, concrete, etc.

- Freeboard - Freeboard is the difference between the design flow elevation in the emergency spillway and the top of the settled embankment. The minimum freeboard for Class 2 and Class 3 basins shall be 1 foot.

Embankment (Earth Fill)

- Class 1 basins - The minimum top width shall be 10 feet. The upstream slope shall be no steeper than 3:1. The downstream slope shall be no steeper than 5:1.

- Class 2 basins - The minimum top width shall be 8 feet. The combined upstream and downstream side slopes shall not be less than 5:1 with neither slope steeper than 2½:1.

- Class 3 basins - The minimum top width shall be 10 feet with a top width of 12 feet for fills over 15 feet in height. Side slopes shall be no steeper than 2½:1.

Embankment (Other than Earth Fill)

- Pressure creosoted timber crip - rock filled.

- Precast reinforced concrete crib - rock filled.

- Gabions.

When the above material is used for the embankment, a principal spillway is not required; however, the dam shall be pervious to allow for drainage during times of low inflow. Basins constructed of the above materials should be used only when the sediment to be trapped is coarse grained material such as GW or GP material (Unified Soil Classification System).

## CONSTRUCTION

### Site Preparation

Areas under the embankment and any structural works shall be cleared, grubbed and the topsoil stripped to remove trees, vegetation, roots and other objectionable material. In order to facilitate cleanout and restoration, the pool area will be cleared of all brush and excess trees.

### Cutoff Trench

A cutoff trench shall be excavated along the centerline of dam on earth fill embankments to a depth of at least 1.0 foot into a layer of slowly permeable material. The minimum depth shall be 2 feet. The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 4 feet, but wide enough to permit operation of compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for embankment. The trench shall be kept free from standing water during the backfilling operations.

### Embankment

The fill material shall be taken from approved designated borrow areas. It shall be free of roots, woody vegetation, oversized stones, rocks or other objectionable material. Areas on which fill is to be placed shall be sacrified prior to placement of fill. The fill material should contain sufficient moisture so that it can be formed into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction.

Fill material will be placed in 6- to 8-inch layers and shall be continuous over the entire length of the fill. Compaction will be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is traversed by at least one tread track of the equipment or compaction shall be achieved by the use of a compactor. The embankment shall be constructed to an elevation 10 percent higher than the design height to allow for settlement if compaction is obtained with hauling equipment. If compactors are used for compaction, the overbuild may be reduced to 5 percent.

330.4 Continued

Pipe Spillways

The riser shall be solidly attached to the barrel and all connections shall be watertight. The barrel and riser shall be placed on a firm foundation. The fill material around the pipe spillway will be placed in 4-inch layers and compacted to at least the same density as the adjacent embankment.

Emergency Spillway (Class 2 and 3 basins)

The emergency spillway shall be installed in undisturbed earth unless specified otherwise in the plan. The lines and grades must conform to those shown on the plans as nearly as skillful operation of the excavating equipment will permit.

Embankment (other than Earth Fill)

The rock used to fill cribbing or gabions will be hard and durable and of an approved size and gradation.

Erosion and Pollution Control

Construction operations will be carried out in such a manner that erosion and water pollution will be minimized. State and local laws concerning pollution abatement shall be followed.

Safety

State requirements shall be met concerning fencing and signs warning the public of hazards of soft sediment and floodwater.

Seeding

Seeding, fertilizing and mulching shall conform to the specifications in the vegetative section for debris, basin, floodwater retarding structures, and grade stabilization structures.

Final Disposal

In the case of temporary structures, when the intended purpose has been accomplished and the drainage area properly stabilized, the embankment and resulting silt deposits are to be leveled or otherwise disposed of in accordance with the plan.

# 330.5 GRADE STABILIZATION STRUCTURE - URBAN AREAS

## Definition

A structure to stabilize the grade or to control head cutting in natural or artificial channels.

## Scope

This standard applies to all types of grade stabilization structures. It does not apply to storm sewers or their component parts.

## Purpose

Grade stabilization structures are used to reduce or prevent excessive erosion by reduction of velocities in the watercourse or by providing channel linings or structures that can withstand the higher velocities.

## Conditions Where Practice Applies

This practice applies to sites where the capability of earth and vegetative measures is exceeded in the safe handling of water at permissible velocities, where excessive grades or overfall conditions are encountered or where water is to be lowered structurally from one elevation to another. These structures should generally be planned and installed along with or as a part of other conservation practices in an overall surface water disposal system.

## PLANNING

## Compliance with Laws and Regulations

Design and construction shall be in compliance with state and local laws and regulations. Such compliance is the responsibility of the landowner or developer.

## General

Designs and specifications shall be prepared for each structure on an individual job basis depending on its purpose, site conditions and the basic criteria of the conservation practice with which the structure is planned. Typical structures are as follows:

- Channel linings of concrete, asphalt, half-round metal pipe or other suitable lining materials. These linings should generally be used where channel velocities exceed safe velocities for vegetated channels due to increased grade or a change in channel cross section or where durability of vegetative lining is adversely affected by seasonal changes. Adequate protection will be provided to prevent erosion or scour of both ends of the channel lining.

- Overfall structures of concrete, metal, rock riprap or other suitable material used to lower water from one elevation to another. These structures are applicable where it is desirable to drop the watercourse elevation over a very short horizontal distance. Adequate protection will be provided to prevent erosion or scour upstream, downstream and along sides of overfall structures.

- Pipe drops of metal pipe with suitable inlet and outlet structures. The inlet structure may consist of a vertical section of pipe or similar material, an embankment or a combination of both. The outlet structure will provide adequate protection against erosion or scour at the pipe outlet.

- The quality, strength, proportioning and placing of pipe, portland cement concrete, asphaltic concrete and other construction materials shall be in accord with applicable SCS standards and specifications.

Capacity

Structures which are designed to operate in conjunction with other erosion control practices shall have as a minimum sufficient capacity of structures that are not designed to perform in conjunction with other practices shall be that required to handle the peak rate of flow from a 24-hour, 25-year frequency storm.

Peak rates of runoff used in determining the capacity requirements shall be determined as outlined in Chapter 2, Estimating Runoff, "Engineering Field Manual for Conservation Practices" or by other accepted methods.

Structures which involve the retarding of floodwater or the impoundment of water shall be designed using the criteria set forth in the standards and specifications for Ponds or Floodwater Retarding Structures, whichever is applicable.

CONSTRUCTION

Structures shall be installed according to lines and grades shown on the plan. The foundation for structures shall be cleared of all undesirable materials prior to the installation of the structure.

Materials used in construction shall be of a permanency commensurate with the design frequency and life expectancy of the practice.

Earth fill, when used as a part of the structure, shall be placed according to the construction specifications for Ponds.

Seeding, fertilizing, and mulching shall conform to the recommendations specifications in the Vegetative Section.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized. State and local laws concerning pollution abatement shall be followed.

330.6 OPEN CHANNEL - URBAN AREAS

Definition

Constructing or improving a channel, either natural or artificial, in which water flows with a free surface.

Scope

This standard covers the construction of open channels or improvement of existing streams or ditches in an urban area.

Purpose

Open channels are constructed or improved and maintained to provide discharge capacity required for flood prevention, drainage, other authorized water management purposes, or any combination of these purposes.

Conditions Where Practice Applies

Provisions of this standard are applicable to all earth channel construction or improvement which includes flood prevention or drainage as a project purpose, alone or in combination with other purposes, except as noted under "Scope" above.

An adequate outlet for the improved channel reach must be available for discharge by gravity flow or pumping.

Construction or other improvements of the channel must not cause significant erosion upstream or increased flooding and/or sediment deposition downstream.

PLANNING

Adequate drainage must have the hydraulic characteristics to accomodate the maximum expected flow of storm waters for a given watershed or portion thereof for a specific duration and intensity of rainfall. Adequate drainage should be designed to:

(1) Account for both off-site and on-site storm waters, including storm waters coming onto a given tract from upstream,

(2) Discharge said water into a natural or man-made drainageway, and

(3) Convey said water to a point where it will flow by gravity downstream into a stream, water channel or drainageway of non-erosive velocity or where it can be connected into existing facilities of sufficient capacity to receive the same.

Channels should be constructed in such a manner that they can be maintained at reasonable cost. To facilitate design, construction and maintenance, said drainage shall be in compliance with Federal, State and local laws and regulations. Said compliance is the responsitility of the landowner, engineer or developer.

Location

The alignment of channels shall not be changed to the extent that the stability of the channel or laterals thereto is endangered.

Channel Capacity

The capacity for open channels shall be determined by procedures applicable to the purposes to be served, and in accord with related Engineering Standards and Handbooks. The "n" value for aged channels, assuming good maintenance, shall be used in this computation. The required capacity may be established by consideration of

volume-duration removal rates, peak flow or a combination of the two as determined by the topography, purpose of the channel, desired level or protection, and economic feasibility.

Level of Protection

Floor elevations of all living units or commercially used buildings shall be such that all floors will be free of storm water of a peak runoff for a 100-year return frequency of a 24-hour duration.

Openings into basements containing no dwellings units or commercial storage space shall be at such elevations that storm water cannot enter the basement through such openings from a peak runoff equivalent to a 50-year return frequency of a 24-hour duration.

The minimum finished grade at the building shall be such that they will not be adversely affected by a peak runoff equivalent to a 50-year return frequency of a 24-hour duration.

Streets shall be useable during runoff from a storm equivalent to a 10-year return frequency of a 24-hour duration.

Hydraulic Requirements

Manning's formula shall be used to determine the velocities in the channels. The "n" values for use in this formula when designing channels to be constructed or improved shall be estimated using NEH-5, Sup. or NEH-16, Chapter 6.

The "Guide for Selecting Roughness Coefficient "n" Values for Channels" compiled by Guy B. Gasken, Soil Conservation Service, USDA, Lincoln, Nebraska, 1963, and U.S. Geological Survey Water Supply Paper 1849, "Roughness Characteristics of Natural Channels" are useful guides in estimating "n" values of existing channels.

Minimum Criteria

(1) Lot drainage - For drainage immediately around the building site refer to Engineering Guides 330.1, "Land Grading - Urban Areas".

(2) For Swales or surface drainage in urban areas for drainage areas up to 20 acres use:

Design Peak Capacity use one c.f.s. per acre of drainage area

Minimum grade - 0.3%

Minimum top width - 8 feet

Minimum depth - 0.5 feet

(3) For outlet channels of drainage areas of 20 to 2000 acres, provide a 10-year frequency peak to the top of the bank.

(4) For drainage areas over 2000 acres, use some type of flood plan study or elevation or IDNR analysis since they will be reviewing this size project.

Peak rates of runoff in determining the capacity requirements shall be determined as outlined in Chapter 2, Estimating Runoff, "Engineering Field Manual for Conservation Practices" or by other acceptable methods. The rational method is one of the most used other acceptable methods for estimating peak runoff. Although it uses an emperical equation, certain modifications based on scientific knowledge provide a direct and feasible method of predicting flood peaks.

The rational equation is $Q = cia$ in which -

Q = Quantity of storm water runoff in cubic feet per second.

a = Drainage area in acres tributory to the point of concentration.

i = Rainfall intensity in acres per hour for the period of concentration to the point under consideration.

c = Coefficient of runoff in the ratio expressing the proportional amount of the rainfall that appears as runoff.

Channel Cross Section

The required channel cross section and grade are determined by the design capacity, the materials in which the

channel is to be constructed, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains, tributary ditches, or streams. Developments through which the channel is to be constructed must be considered in design of the channel section.

Earthen channel side slopes shall be no steeper than 2 to 1. Flatter slopes may be required to prevent erosion and for ease of maintenance. Where channels will be lined, side slopes shall be no steeper than 1½:1 with adequate provision made for weep hole drainage. Side slopes steeper than 1½:1 may be used for lined channels provided that the side lining is designed and constructed as a structural retaining wall with provision for live and dead surcharge load.

Channel Stability

Characteristics of a stable channel are:

- It neither aggrades or degrades beyond tolerable limits.

- The channel banks do not erode to the extent that the channel cross section is changed appreciably.

- Excessive sediment bars do not develop.

- Excessive erosion does not occur around culverts and bridges or elsewhere.

- Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel.

All channel construction and improvement shall be in accord with a design which can be expected to result in a stable channel which can be maintained at reasonable cost.

The effect of dikes or continuous spoil that confine the flow of water in channel floodways will be considered in determining bankfull stage and discharge.

Bankfull flow is defined as the flow in the channel which creates a water surface that is at or near normal ground elevation for a significant length of a channel reach. Excessive channel depth created by cut through high ground, such as might result from realignment of the channel, should not be considered in determinations of bankfull flow.

Channel stability shall be determined for an aged condition and the velocity shall be based on the design flow or the bankfull flow, whichever is greater, using an "n" value based on the expected kind and density of vegetation and assuming good maintanance. In no case is it necessary to check channel stability for discharges greater than that from the 100-year frequency storm. The discharge used in stability analysis of channels having a controlled inflow shall be their design flow.

Channels also must be stable under conditions existing immediately after construction. For this stability analysis the velocity shall be calculated for the expected flow from a ten-year frequency storm on the watershed, or the bankfull flow, whichever is smaller, and the "n" value for the newly constructed channel shall be used. The "n" values of newly constructed channels in fine-grained soils and sands shall be determined in accord with NEH-5, Sup. B, and shall not exceed 0.025. The "n" value for channels to be improved by clearing and snagging only shall be determined by reaches according to the expected channel condition upon completion of the work.

In the humid sections of the United States, the allowable velocity in the newly constructed channel may be increased by maximum of 20 percent to reflect the effects of vegetation to be established under the following conditions:

- The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion controlling vegetation.

- Species of erosion controlling vegetation adapted to the area, and proven methods of establishment are known.

- The channel design includes detailed plans for establishment of vegetation on the channel side slopes.

Travelways for Maintenance

Travelways for maintenance shall be provided as a part of all channel improvement. A travelway shall be provided on each side of large channels if necessary for use of maintenance equipment.

Travelways must be adequate for movement and operation of equipment required for maintenance for the channel. The travelway may be located adjacent to the channel on a berm or on the spread spoil. In some situations the channel itself may be used as the travelway.

Appurtenant Structures

The design of channels will provide for all structures required for the proper functioning of the channel and the laterals thereto and travelways for operation and maintenance. Recessed inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the design of channel improvements. The design also is to provide for necessary flood gates, water level control devices, bays used in connection with pumping plants and any other appurtenances affecting the functioning of channels and the attainment of the purposes for which they are built. If the improved channel bottom elevation is below the elevation of the bottom of a lateral channel at their junction to the extent that a recessed inlet is not feasible, the lateral channel must be stabilized by a sound durable structure.

The effect of channel improvements on existing culverts, bridges, buried cables, pipelines, irrigation flumes and inlet structures for surface and subsurface drainage on the channel being improved and laterals thereto shall be evaluated to determine the need for modification or replacement.

Culverts and bridges which are modified or added as part of channel improvement projects shall meet reasonable standards for the type of structure, and shall have a minimum capacity equal to the design discharge or state agency design requirements, whichever is greater. When the design discharge is based on storms which occur frequently, i.e., storms of one or two-year frequency, it may be desirable to increase the capacity of culverts and bridges above the design discharge.

Disposition of Spoil

Spoil material resulting from clearing, grubbing and channel excavation shall be disposed of in a manner which will:

- Minimize overbank wash.

- Provide for the free flow of water between the channel and flood plain unless the valley routing and water surface profile are based on continuous dikes being installed.

- Not hinder the development of travelways for maintenance.

- Leave the right-of-way in the best condition feasible, consistant with the project purposes, for productive use by the owner.

- Improve the esthetic appearance of the site to the extent feasible.

## CONSTRUCTION

Specifications shall be in keeping with the preceding standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

330.6 Continued

SUGGESTED VALUES FOR URBAN AREAS

| Zoning Classification | Rational Formula Runoff Coefficient "c" | SCS Engr - Field Manual Curve Number |
|---|---|---|
| Business, Industrial Commercial | 0.83 to 0.85 | 90 |
| Apartment Houses | 0.70 to 0.75 | 88 |
| Schools | 0.53 to 0.59 | 85 |
| Urban Residential (Lots 10,000 sq. ft. ±) | 0.44 to 0.51 | 84 |
| Suburban Residential (Lots 12,000 sq. ft. ±) | 0.39 to 0.47 | 82 |
| Suburban Residential (Lots 17,000 sq. ft. ±) | 0.37 to 0.45 | 82 |
| Suburban Residential | 0.33 to 0.43 | 82 |
| Parks and Cemeteries | 0.31 to 0.39 | 81 |
| Unimproved Areas | 0.24 to 0.33 | 80 |

330.7 DRAINS - URBAN AREAS

Definition

A conduit, such as tile, pipe, or tubing, installed beneath the ground surface and which collects and/or conveys drainage water.

Purpose

A drain may serve one or more of the following purposes:

- Improve the developed area by lowering the water table.
- Intercept and prevent water movement into a wet area.
- Relieve artesian pressures.
- Remove surface runoff.
- Serve as an outlet for other drains.

Conditions Where Practice Applies

Drains are used in areas having a high water table where benefits of lowering or controlling groundwater or surface runoff justify the installation of such a system.

All lands to be drained shall be suitable for urban development after installation of required drainage and other conservation practices. The soil shall have enough depth and permeability to permit installation of an effective and economically feasible system.

An outlet for the drainage system shall be available, either by gravity flow or by pumping. The outlet shall be adequate for the quantity and quality of effluent to be disposed of with consideration of possible damages above or below the point of discharge that might involve legal actions under state laws.

PLANNING

The design and installation shall be based on adequate surveys and investigations. The Indiana Farm Drainage Guide, Table 1, "Drainage Recommendations for Indiana Soils" shall be followed as a guide for urban area development.

Required Capacity of Drains

The required capacity shall be determined by one or more of the following:

- The system shall have sufficient capacity to drain all areas in the watershed needing drainage.

- A suitable coefficient including capacity required to dispose of surface water entering through inlets.

- Survey and comparison of the site with other similar area sites where subsurface drain yields have been measured.

- Measurement of the rate of subsurface flow at the site.

- Estimates of lateral or artesian subsurface flow.

- Grassed Waterways, Swales or Outlets shall be used to remove surface water from the land where feasible for the most economical and satisfactory results.

When an existing main is to be used for an outlet the following shall apply:

CASE I - For areas to be drained that are five acres or less.

This will apply principally to small systems and random lines where complete extensive systems are not needed.

An investigation shall be made of the outlet tile to determine that:

- It is in good physical condition based on observations of the outlet tile at point of junction.

- It has adequate capacity based on general observations made in the field. A survey or instrument check of the tile main downstream a distance of 200 to 300 feet from the junction is advisable to determine grade. It will not be necessary to continue this check to the outlet unless observations indicate the advisability of such survey.

- It has sufficient depth to provide minimum cover for all new lines to be installed.

- The existing tile outlet is adequate, if readily avilable and nearby.

CASE II - For areas to be drained in excess of five acres.

The investigation shall include the following:

- A physical inspection of the existing tile to determine that the tile is operative, free from breakdowns, and has an adequate outlet.

  The existing tile will be considered adequate if the capacity of the time, as determined in Step 2, is equal to, or greater than 80% of the required capacity, and if the existing tile is not deteriorated because of holes, quartering, roots or submergence of the outlet, except where such damages are repaired, and/or corrected.

- Determine the capacity of the existing tile by checking the grades and sizes in the critical areas, particularly the flat reaches.

Definition of Physical Inspection

The physical inspection will constitute the observing of the physical condition of the tile for the following conditions. The physical inspection shall extend from the outlet upward:

- Breakdowns in the tile line which are usually accompanied by holes in the land over and along the line.

- Fractured tile, such as quartering of tile (fractures on the quarter points which result in an egg-shape cross-section).

- Deposition of soil in the tile line. If excessive deposition appears, make a further study to determine the cause and plan for correction.

- Physical deterioration of the tile material that would seriously subject it to failure, due to high absorption rate, soil acidity, or alkalinity, etc.

If the outlet tile is a drain of record (court drain), all the information available from the record, should be used in making the determination as to the adequacy of the tile outlet.

Size of Drain

The size of drains shall be computed by applying Manning's formula. The required capacity shall be determined as provided above and the size computed based on one of the following assumptions:

- Hydraulic grade line parallel to the bottom grade of the drain with the drain flowing full at design flow.

- The drain flowing part full where a steep grade or other condition requires excess capacity.

- Drain flowing under pressure with hydraulic grade line set by site conditions on a grade which differs from that of the drain. This procedure shall be used only where surface water inlets or nearness of the drain to outlets with fixed water elevations permit satisfactory estimates of hydraulic pressure and flows under design conditions.

The size may be determined from Standard Drawing Number ES-714 (Exhibit 14-11 Engineering Field Manual) or from the "Tile Drain Design Chart" in the Indiana Drainage Guide.

The minimum size of drain shall be four inches in diameter except as follows. The minimun size of drain shall be six inches in diameter for deep organic soils (drainage group 19), and five inches in diameter for sandy soils (drainage group 13) except when drain lengths of thirty feet or longer are used.

Depth, Spacing, and Location

The depth, spacing, and location of the drain shall be based on site conditions including soils, topography, groundwater conditions, building locations and outlets.

The minimum depth of cover in organic soils shall be 30 inches for normal field levels as defined above, after initial subsidence.

Structural measures shall be installed where feasible to control the water table level in organic soils within the optimum range of depths.

The Indiana Drainage Guide "Drainage Recommendations for Indiana Soils" shall be used as a guide for making determinations of depth, spacing and location.

Minimum Velocity and Grade

Where it is determined that a silting hazard exists, a velocity of not less than 1.4 feet per second shall be used to establish the minimum grades or the Indiana Drainage Guide "Drainage Recommendations for Indiana Soil" may be used, if site conditions permit. Provisions shall be made for prevention of siltation by filters as recommended in the Indiana Drainage Guide, and collection and removal of silt by use of silt traps when specified in the plans.

In areas with no rapid siltation hazard the minimum grade will be as follows except where tile is also used for subsurface irrigation or unusual site conditions exist:

| | |
|---|---|
| 4 inch diameter | 0.10% |
| 5, 6, 7 inch diameter | 0.07% |
| 8, 10 inch diameter | 0.06% |
| 12 inch diameter & over | 0.05% |

Maximum Grade and Protection

On sites where topographic conditions require the use of drain lines on grades steeper than two percent or where design velocities will be greater than indicated in the table below, special measures shall be used to protect the drain. These measures shall be specified for each job based on the particular conditions of the job site. The protective measures shall be specified for each job based on the particular conditions of the job site. The protective measures shall include one or more of the following:

- Use only drains that are uniform in size and shape and with smooth ends.

- Lay the drains so as to secure a tight fit with the inside diameter of one section matching that of the adjoining sections.

- Wrap open joints with tar impregnated paper, burlap, or special filter material such as plastic or fiber-glass fabrics.

- Select the least erodible soil available for blinding.

- Tamp blinding material carefully around the drain before backfilling.

- Seal joints or use a watertight pipe.

- For continuous pipe or tubing with perforations, completely enclose the pipe with filter material of plastic, fiber glass, or properly graded sand and gravel.

Maximum Permissible Velocity in Drains Without Protective Measures

| Soil Textures | Velocity - ft/sec |
|---|---|
| Sand and Sandy Loam | 3.5 |
| Silt and Silt Loam | 5.0 |
| Silty Clay Loam | 6.0 |
| Clay and Clay Loam | 7.0 |
| Coarse Sand or Gravel | 9.0 |

Materials for Drains

"Drains" include conduits of clay, concrete, bituminized fiber, metal, plastic, or other materials of acceptable quality.

The conduit shall meet strength and durability requirements of the site. Current Specifications as listed below or as included in the specifications guide shall be used in determining the quality of the conduit.

The minimum standards shall be these currently established for "Standard Drain Tile" by ASTM.[1]

[1]American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103

Concrete Tile - The use of concrete tile under acid and sulfate conditions shall be in accord with the following guides:

ACID SOILS

| Class of Tile | Lower Permissible Limits of pH Values[3] | |
|---|---|---|
| | Organic & Sandy Soils | Medium & Heavy Textured Soils |
| ASTM C 412: | | |
| Standard Quality | 6.5 | 6.0 |
| Extra Quality | 6.0 | 5.5 |
| Special Quality | 5.5 | 5.0 |
| ASTM C 14, C 118, C 444 | 5.5 | 5.0 |

Other Clay and Concrete Pipe

Bell and spigot, tongue and groove, and other pipe which meets the strength, absorption, and other requirements of clay or concrete tile as covered above, except for minor imperfections in the bell, the spigot tongue or the groove, and ordinarily classed by the industry as "seconds", may be used for drainage conduits provided the pipe is otherwise adequate for the job.

Foundation Requirements

Soft or yielding foundations shall be stabilized where required and lines protected from settlement by adding gravel or other material to the trench, placing the conduit or plank or other rigid supports, or using long sections of perforated or watertight pipe.

Loading

The allowable loads on drain conduits shall be based on the trench and bedding conditions specified for the job. A factor of safety of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit. Bedding requirements shall be specified in accordance with the specifications guide. To determine maximum trench depths Table 14-6 of the Engineering Field Manual or Table 4 of the Indiana Farm Drainage Guide may be used.

[3]Figures given represent lowest readings of pH values for soil water or soil at tile depth.

Filters and Filter Material

Suitable filters shall be used around drains where recommended in the Indiana Farm Drainage Guide, "Drainage Recommendations for Indiana Soils," to prevent sediment accumulation in the conduit.

Not less than three inches of filter material shall be used for sand-gravel filters. A recommended method of installation is to place filter material to a depth of three inches under the drain, and cover the drain and filter with a sheet of plastic. The filter shall be designed to prevent the material in which the installation is made from entering the drain. Not more than ten percent of the filter shall pass the No. 60 sieve.

Where fiber-glass filter material is used, it shall be manufactured from borosilicate type glass and the manufacturer of the material shall certify that it is suitable for underground use. The fibers shall be of variable size, with some larger fibers intertwined in the mat in a random manner. The material shall cover all open joints and perforations.

Blinding Material

Top soil shaved from the side of the trench or equally friable soil shall be used to blind the drain for those soils that filters are not recommended.

Envelopes and Envelope Material

Envelopes shall be used around drains where required for proper bedding of the conduit, or where necessary to improve the characteristics of flow of ground water into the conduit.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they shall not contain materials which will cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit.

Auxiliary Structures and Drain Protection

The outlet shall be protected against erosion and undermining of the drain, against damaging periods of submergence, and against entry of rodents or other animals into the

drain. A continuous section of pipe without open joints or perforations shall be used at the outlet end of the line and shall outlet above the normal elevation of low flow in the outlet ditch.

The pipe and its installation shall conform to the following requirements:

- Where there is a hazard of burning to vegetation on the outlet ditch bank, the material from which the outlet pipe is fabricated shall be fire resistant. Where the hazard of burning is high, the outlet pipe shall be fireproof.

- Two-thirds of the pipe shall be buried in the ditch bank and the cantilevered section shall extend beyond the toe of the ditch side slope or the side slope shall be protected from erosion. The minimum length of pipe shall be ten feet.

- Where ice or floating debris may damage the outlet pipe, the outlet shall be recessed to the extent that the cantilevered portion of the pipe will be protected from the current in the ditch.

- Headwalls which are used for drain outlets shall be adequate in strength and design to avoid washouts and other features.

Conduits under roadways shall be designed to withstand the expected loads. Shallow drains through depressional areas and near outlets shall be protected against hazards of farm and other equipment, and freezing and thawing.

Junction boxes shall be used where more than two main lines join.

Where surface water is to be admitted to drains, inlets shall be designed to exclude debris and prevent sediment from entering the conduit. Drain lines flowing under pressure shall be designed to withstand the resulting pressures and velocity of flow. Auxiliary surface waters shall be used where feasible.

## CONSTRUCTION

Specifications shall be in keeping with the preceding standard, shall describe the requirements for proper installation of the practice to achieve its intended purpose, and shall include consideration of the following items:

Inspection and Handling of Material

Material for drains shall be given a rigid inspection before installation. Where applicable, clay and concrete tile shall be checked for damage from freezing and thawing prior to installation. Bituminized fiber and plastic pipe and tubing shall be protected from hazards causing deformation or warping. All material shall be satisfactory for its intended use and shall meet applicable specifications and requirements.

Placement

All drains, both flexible as plastic tubing and non-flexible as clay and concrete tile, shall be laid to line and grade and covered with approved blinding, envelope, or filter material to a depth of not less than three inches over the top of the drain the same day that the drain is laid. Either of the two methods below may be used.

- Except as provided in Method 2 below, the bottom of the excavated trench shall be shaped or grooved. Flexible type drains, when placed, shall be embedded in undisturbed soil for approximately 60 degrees of their circumference. After placement of all types of drains, friable material taken from the trench spoil or cut from the trench side walls shall be placed around the drain in such a manner that it will completely surround and support the drain and fill the trench to a depth of three inches over the top of the drain. To be suitable, materials surrounding the drain must contain no hard clods, rocks, or fine materials which would cause a silting hazard in the drain.

- When special shaping or grooving of the trench bottom is not provided to embed the drain when placed, the drain shall be laid directly upon the flat, unshaped bottom and both sides covered with an envelope material of sufficient quantity to fill the trench to a depth of three inches over the top of the drain. Envelope material shall consist of sand-gravel material, all of which shall pass a 1½ inch sieve, 90 to 100 percent shall pass the 3/4 inch sieve, and not more than 10 percent shall pass the No. 60 sieve.

When a filter is required, all openings in the drain shall be covered by the filter, or approximately the lower half of the drain is to be covered by the filter and the rest of the drain covered by a sheet of impervious plastic. No portion of the drain containing openings is to be left exposed under conditions which require the use of a filter.

When sand-gravel filter material is used, the trench shall be over excavated three inches and backfilled to grade with filter material. After placement of the drain upon the filter material, additional filter material shall be placed over the drain to fill the trench to a depth of three inches over the drain. A plastic sheet and friable soil can be used in lieu of filter material as the backfill over the drain when specified. The sand-gravel filter material shall be a mixture of sand and gravel within the gradation required by the base material in the trench.

The gap between tile or other drain pipe joints shall not exceed 1/4 inch for mineral soils or 1/2 inch for organic soils. Openings wider than these, occurring on the outer side of a curve in a tile line or due to tile irregularity, shall be permitted if they are covered with broken tile, fiber glass, or other suitable material.

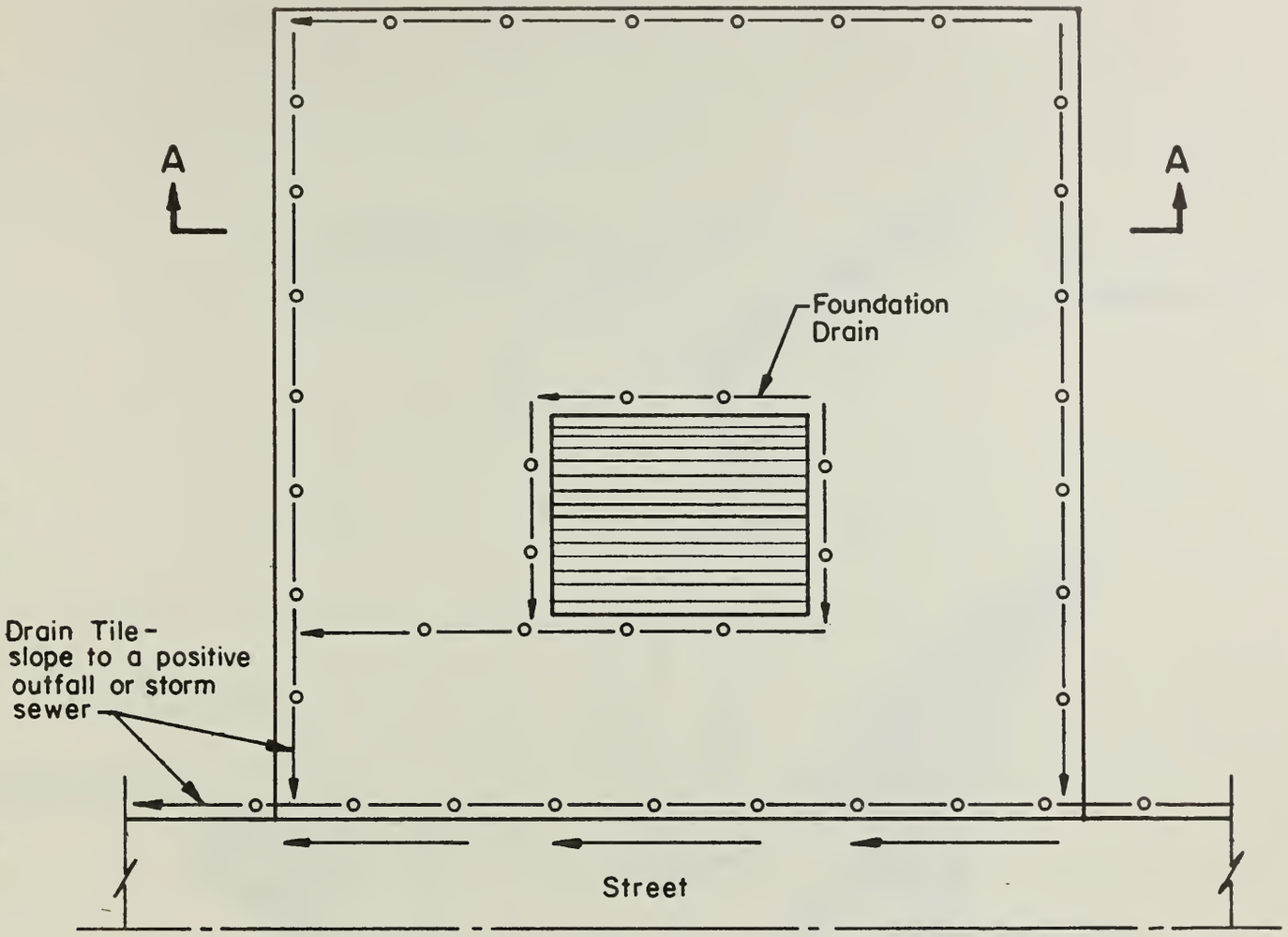
The upper end of each drain line shall be capped with concrete or other durable material unless connected to a structure.

Earth backfill material shall be placed in the trench in such a manner that displacement of the drain will not occur and so that the filter and bedding material, after backfilling, will meet the requirements of the plans and specifications.

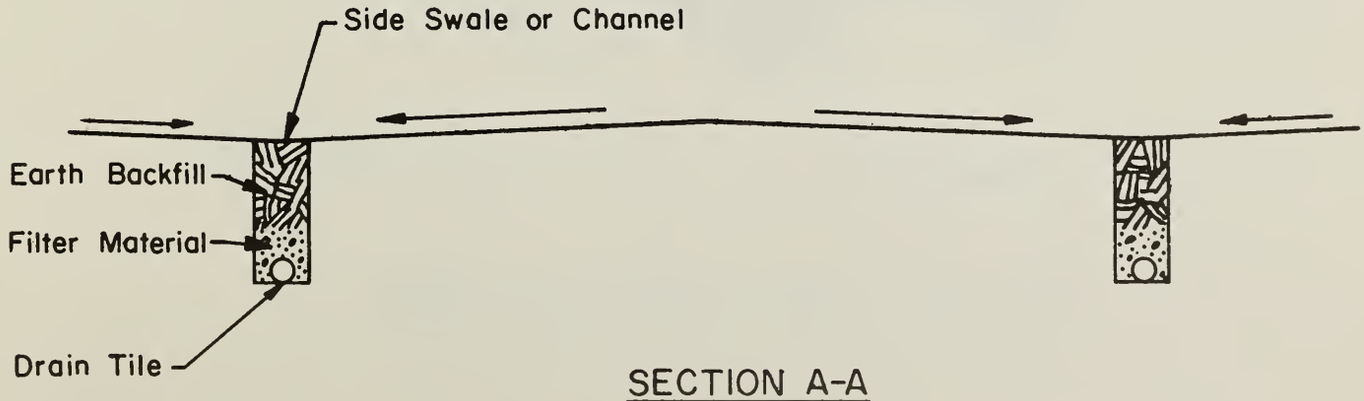
No reversals in grade of the conduit shall be permitted.

Where the conduit is to be laid in a rock trench, or where rock is exposed at the bottom of the trench, the rock shall be removed below grade enough that the trench may be backfilled, compacted, and bedded; and when completed, the conduit shall be not less that two inches from rock.

# DRAINS - URBAN AREAS




PLAN



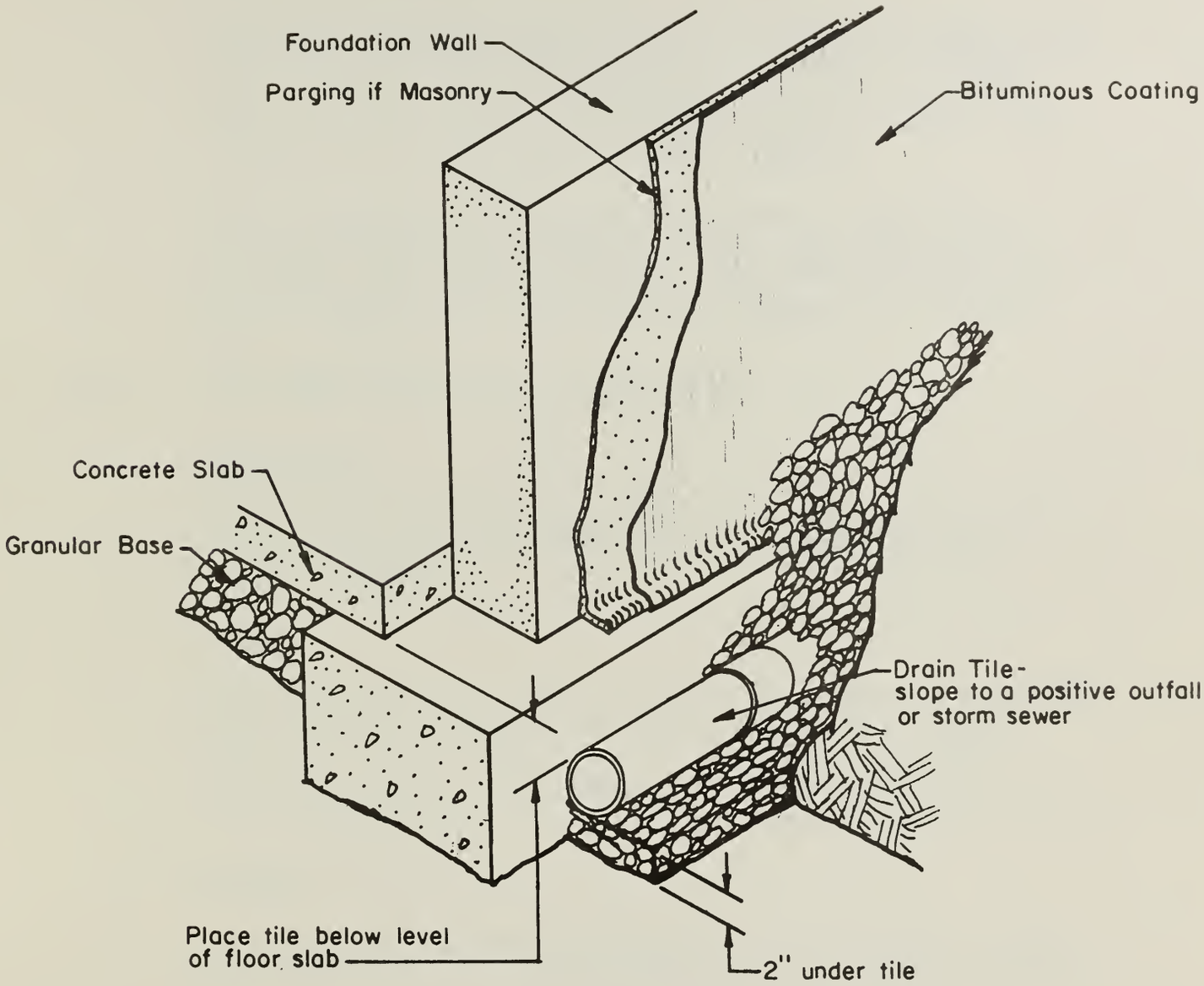

SECTION A-A

## EXAMPLE: SUB-SURFACE LOT DRAINAGE TYPE I

(All drainage to front of lot)

| REFERENCE | US DEPARTMENT OF AGRICULTURE<br>SOIL CONSERVATION SERVICE<br>INDIANA | |
|---|---|---|

# DRAINS - URBAN AREAS




DRAIN TILE ALONG SIDE OF FOOTING

## EXAMPLE: FOUNDATION DRAINS AND DAMPPROOFING

REFERENCE
"Minimum Property Standards for One and Two Living Units"
HUD-FHA
November 1966 FHA No. 300

US DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
INDIANA

Materials

All materials currently acceptable for installation as drains are listed in the standards for drains.

Working Tools and References

Working tools and references are to be used as guides along with local experience in planning and installing drains, except when the wording of this standard indicates otherwise. In those cases, the specific table, figure or part referred to becomes a part of this standard.

Engineering Field Manual for Conservation Practices, National Engineering Handbook, Chapter 16; Drainage Farm Drainage - USDA Farmers Bulletin 2046, Subsidence of Muck Soil in Northern Indiana, SC-366, Indiana Farm Draining Guide - Purdue.

330.8 STREAMBANK PROTECTION - URBAN AREAS

Definition

Stabilizing and protecting banks of streams or excavated channels against scour and erosion by vegetative and structural means.

Scope

This standard covers the structural means used to stabilize and protect the banks of natural streams and excavated channels. It does not cover the vegetative measures which may be used for streambank protection, either when used alone or to supplement the mechanical measures.

Purpose

Streambank protection is established to stabilize or protect streambanks for one or more of the following purposes:

- To prevent the loss of land or damage to utilities, roads, buildings, or other facilities adjacent to the channel.

- To maintain the capacity of the channel.

- To control channel meander which would adversely affect downstream facilities.

- To reduce sediment loads causing downstream damages or to improve the stream for recreational use or as a habitat for fish and wildlife.

Conditions Where Practice Applies

This practice applies to natural or excavated channels where the streambanks are subject to erosion from the action of water, ice or debris or to damage from livestock, pedestrian or vehicular traffic.

PLANNING

Since each reach of channel is unique, measures for streambank protection must be installed according to a plan and adapted to the specific site. Designs will be developed in accordance with the following principles:

- Protective measures to be applied will be compatable with improvements planned or being carried out by others.

- The grade must be controlled, either by natural or artificial means, before any permanent type of bank protection can be considered feasible unless the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.

- Streambank protection will be started at a stabilized or controlled point and ended at a stabilized or controlled point on the stream.

- Needed channel clearing to remove stumps, fallen trees, debris and bars which force the streamflow into the streambank will be an initial element of the work.

- Changes in channel alignment will be made only after an evaluation of the effect on the land use, interdependent water disposal systems, hydraulic characteristics, and existing structures.

- Structural measures must be effective for the design flow and be able to withstand greater floods without serious damage.

- Vegetative protection will be considered on the upper portions of eroding banks and especially on those areas which are subject to infrequent inundation.

Streambank Protection Measures

The following is a partial list of elements which may be involved in a plan for streambank protection. For more details on these installations see Chapter 16 of Engineering Field Manual.

Obstruction Removal

The removal of fallen trees, stumps, debris, minor ledge outcroppings and sand and gravel bars that may cause local current turbulence and deflection.

Clearing

The removal of trees and brush which adversely affect the growth of desirable bank vegetation. Trees of 4-inch diameter and larger on the bank which are in danger of undercutting and falling into the channel should be cut off and removed. The same is true for those trees which might collect debris and ice drifts along the channel banks. In some cases of unstable soils, the weight of growing trees near the channel causes the sloughing of large sections of streambank. These also should be removed. The cleared trees may be used to construct a tree revetment at the site or an adjacent site. Vegetative growth on the banks, such as brush and grasses, may be trimmed if necessary, but generally is left for bank protection.

Banksloping

The reduction of the slope of streambanks to provide a suitable condition for vegetative protection for the installation of structural bank protection.

Jetted Willow Poles for Bank Protection

Drive or jet in willow poles on the eroding bank at or just above the normal waterline.

Streambank Control with Jacks

A method of streambank control which can be used consists of placing one or more rows of "Jacks" along the streambank. These jacks are constructed by cutting these poles 10 to 16 feet in length, depending on the depth of the stream which is to be controlled. These poles are crossed and wired together at the midpoints. The ends are then tied together with No. 9 wire.

Riprap or Slope Paving Blocks

Placed or dumped heavy stone, or slope paving blocks, properly underlaid with a filter blanket when necessary, to provide armor protection for streambanks. For successful riprapping, the toe of the revetment must be firmly established.

Jetties

Deflectors constructed of posts, piling, fencing, rock brush or other materials which project into the stream to protect banks at curves and reaches subjected to impingement by high velocity currents.

Revetments

Pervious or impervious structures built on or parallel to the stream to prevent scouring streamflow velocities adjacent to the streambank. Some types of revetments are, tree revetments, piling revetments with wire facing and brush mat revetments.

Fencing

Artificial obstructions to protect vegetation needed for streambank protection or to protect critical areas from damage form stock or pedestrian trails, or vehicular traffic.

Legal requirement

All work planned and constructed must comply with applicable state laws.

Maintenance

Continued maintenance of complete streambank control measures is essential to avoid future, and possible greater, streambank damage. In planning for maintenance, it is important to keep the following points in mind:

- Control measures, once installed, are not automatically permanent. Usually it is not economical to establish absolutely permanent controls.

- The nature of the maintenance differs in different parts of the general drainage area owing to extremes in physical characteristics of rivers and creeks.

330.8 Continued

Because the meandering of currents at flood or high-water stages cannot be determined precisely in advance, the amount and intensity of treatment needed cannot be completely foreseen at the start. Careful examination of plantings and structures during the first four years following installation will disclose points of weakness and where sections likely to give way should be strengthened.

330.9 FLOODWATER RETARDING STRUCTURE - URBAN AREAS

Definition

A barrier or dam constructed across a waterway or at other suitable locations to provide for temporary storage of floodwater and for its controlled release.

Scope

This standard covers the installation of floodwater retarding structures on sites where: (1) failure of the structure would not result in loss of life or interruption of use of service of public utilities (SCS Hazard Class A); and (2) the drainage area does not exceed 100 acres; and (3) the water surface area at the crest of the emergency spillway does not exceed 5 acres. For the purpose of this standard floodwater retarding structures are classified according to the following table:

| Class | Maximum Drainage Area (acres) | Maximum Height of Dam (ft) 2/ | Design 3/ Frequency (24 hr storm AMC-II) | Total Emergency Spillway Capacity (24 hr storm) | Top of Fill |
|---|---|---|---|---|---|
| 1 1/ | 40 | 5 | Route Q 10 4/ | 1 cfs per acre of watershed | 1 foot freeboard above design flow in emergency spillway |
| 2 | 40 | 10 | Route Q 10 4/ | 0.5 Q 25 peak | |
| 3 | 200 | 20 | Route Q 25 4/ | 0.5 Q 50 peak | |

1/ Class 1 basins are to be used where site conditions are such that it is impossible to obtain the total storage capacity above the existing ground line and some storage may be obtained in an excavated area below natural ground.

2/ Height is measured from the low point in the natural stream bed along the centerline of dam to the top of dam for Class 1 and to the crest of the emergency spillway for Classes 2 and 3.

3/ The design frequency is that storm frequency which will be used to evaluate the site. For further explanation of design frequency, see Planning.

4/ Storage may be determined by short cut methods.

Purpose

To detain and control runoff from rainfall and release the runoff at a rate that will prevent or reduce floodwater damage downstream from the structure or control the peak runoffs for a certain return frequency storm to the same peak prior to development.

Condition Where Practice Applies

Where it is desired by the developers and landowners to control the peak runoffs for a certain frequency and duration storm to the same peak after development as to what it was prior to development. This type structure may also be used in conjunction with a debris basin to also reduce sedimentation.

PLANNING

The design frequency is that storm recurrence frequency to be used to evaluate the site under study. The capacity of detention will be such that the design will provide for outflow no greater than that present before development for the same storm frequencys.

Spillway Design

Peak runoff can be computed by the method outlined in Chapter 2, Estimating Runoff "Engineering Field Manual for Conservation Practices" or other accepted methods. For one other acceptable method see Engineering Guidelines, 330.6 Open Channel - Urban Areas. Runoff computations should be based upon the soil cover conditions expected to prevail after total development.

For Class 1 & 2 Structures, the combined capacities of the principal and emergency spillways will be sufficient to pass the peak rate of runoff from a 10-year frequency storm after adjusting for flood routing (Method of Short Cut Flood routing shown in SCS Engineering Field Manual page 11-55 may be used).

For Class 3 Structures, the combined capacities of the principal and emergency spillways will be sufficient to pass the peak rate of runoff from a 25-year frequency storm after adjusting for flood routing (Method of Short Cut Flood routing shown in SCS Engineering Field Manual page 11-55 may be used).

Pipe Spillways

The pipe spillway may consist of a straight pipe, of a vertical pipe or box-type riser jointed to a conduit which will extend through the embankment and outlet beyond the downstream toe of the fill. The minimum diameter of the conduit will be 8 inches. The riser may be perforated to provide for a gradual drawdown after each storm event. The rise of hte principal spillway shall be a cross-sectioned area at least 1.3 times that of the barrel.

- Crest Elevation - The crest elevation of the riser shall be at least 3 feet below the top elevation of the embankment.

- Perforated Riser - Pipe riser may be perforated with 1½ inches diameter holes spaced 8 inches vertically and 10-12 inches horizontally around the pipe. Box-type risers shall be posted or have some means for complete drainage of the sediment pool with a 5 day period following storm inflow.

- Anti-Vortex Device - An anti-vortex device shall be installed on the top of the riser.

- Base - The riser shall have a base attached with a water tight connection. The base shall have sufficient weight to prevent flotation of the riser.

- Trash Rack - An approved trash rack shall be firmly attached to the top of the riser if the pipe spillway conveys 25 percent or more of the peak rate of runoff from the design storm.

- Anti-Seep Collars - Anti-seep collars shall be installed around the pipe conduit within the normal saturation zone when any of the following conditions exist:

    - The settled height of dam exceeds 10 feet.

    - The conduit is of smooth pipe larger than 8 inches in diameter.

    - The conduit is of corrugated metal pipe larger than 12 inches in diameter.

  The anti-seep collars and their connections to the pipe shall be water tight. The maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe but shall not exceed 25 feet.

- Outlet Protection - Protection against scour at this discharge end of the pipe spillway shall be provided. Protective measures may include structures of the impact-basin type, rock riprap, paving, revetment, excavation of plunge pool or use of other approved methods.

Emergency Spillway - Class 2

An emergency spillway shall be excavated in undisturbed ground where site conditions permit. The emergency spillway cross section shall be trapezoidal with a minimum bottom width of 8 feet.

Class 1 Structures

The embankment may be used as an emergency spillway. In these cases the downstream slope of the embankment shall be 5.1 or flatter and this embankment must be immediately protected against erosion by means such as sodding, rock riprap, asphalt coating or other approved methods.

- Capacity - The minimum capacity of the emergency spillway shall be that required to pass the peak rate of the runoff from the design storm, less any reductions due to flow in the pipe spillway and storage. Emergency spillway dimensions can be determined by using the method outlined in Chapter 11 of "Engineering Field Manual for Conservation Practices."

- Velocities - The maximum allowable velocity of flow in the exist channel shall be 6 feet per second for vegetated channels. For channels with erosion protection, other than vegetation, velocities shall be in the safe range for the type of protection used.

- Erosion Protection - Provide for erosion protection by vegetation or by other suitable means such as rock riprap, asphalt, concrete, etc.

- Freeboard - Freeboard is the difference between the design flow elevation in the emergency spillway and the top of the settled embankment. The minimum freeboard for Class 2 structures shall be 1 foot.

Embankment and Earth Fill

- Class 1 Structures - The minimum top width shall be 10 feet. The upstream slope shall be no steeper than 3:1. The downstream slope shall be no steeper than 5:1.

- Class 2 Structures - The minimum top width shall be 8 feet. The combined upstream and downstream side slopes shall not be less than 5:1 with neither slope steeper than 2½:1.

- Class 3 Structures - The minimum top width shall be 10 feet with a top width of 12 feet for fills over 15 feet in height.

## CONSTRUCTION

Site Preparation

Areas under the embankment and any structural works shall be cleared, grubbed and the topsoil stripped to remove trees, vegetation, roots and other objectionable material. In order to facilitate cleanout and restoration, the pool area will be cleared of all brush and excess trees.

Cutoff Trench

A cutoff trench shall be excavated along the centerline of dam on earth fill embankments to a depth of at least 1.0 foot into a layer of slowly permeable material. The minimum depth shall be 2 feet. The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 4 feet, but wide enough to permit operation of compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for embankment. The trench shall be kept free from standing water during the backfilling operations.

Embankment

Fill material shall be taken from approved designated borrow areas. It shall be free of roots, woody vegetation, oversized stones, rocks or other objectionable material. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material should contain sufficient moisture so that it can be formed into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction.

Fill material will be placed in 6 to 8 inch layers and shall be continuous over the entire length of the fill. Compaction will be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is traversed by at least one tread track of the equipment or compaction shall be achieved by the use of a compactor. The embankment shall be ocnsturcted to an elevation 10 percent higher than the design height to allow for settlement if compaction is obtained with hauling equipment. If compactors are used for compaction, the overbuild may be reduced to 5 percent.

Pipe Spillways

The riser shall be solidly attached to the barrel and all connections shall be watertight. The barrel and riser shall be placed on a firm foundation. The fill material around the pipe spillway will be placed in four inch layers and compacted to at least the same density as the adjacent embankment.

Emergency Spillway (Class 2 Basins)

The emergency spillway shall be installed in undisturbed earth unless specified otherwise in the plan. The lines and grades must conform to those shown on the plans as nearly as skillful operation of the excavating equipment will permit.

Embankment (other than Earth Fill)

The rock used to fill cribbing or gabions will be hard and durable and of an approved size and gradation.

Erosion and Pollution Control

Construction operations will be carried out in such a manner that erosion and water pollution will be minimized. State and local laws concerning pollution abatement shall be followed.

Safety

State requirements shall be met concerning fencing and signs warning the public of hazards of soft sediment and floodwater.

Seeding

Seeding, fertilizing and mulching shall conform to the specifications in the vegetative section for debris basins, floodwater retarding structures and grade stabilization structures.

Final Disposal

In the case of temporary structures, when the intended purpose has been accomplished and the drainage area properly stabilized, the embankment and resulting silt deposits are to be leveled or otherwise disposed of in accordance with the plan.

## 400 VEGETATIVE PHASE - SOIL AND WATER MANAGEMENT SYSTEMS

### 410 GENERAL PRINCIPLES INVOLVED

Several broad principles involving vegetation and sediment control in urban areas need to be recognized. These are:

- Apply needed ground cover on exposed areas within 15 days of exposure, except on sites where construction will begin within 30 days. If construction plans are suspended, areas should be seeded down or mulched without delay.

- Select species that are adapted to the site and purpose of planting.

- Avoid burning of vegetative cover, wherever possible. Burned areas become vulnerable to erosion and add to air pollution.

- Limit grades of slopes so plants may be easily established.

- Stockpile topsoil to apply on sites that are otherwise unsuited for establishing vegetation.

- Retain and protect trees and other natural plants wherever possible.

### 420 PLANNING VEGETATIVE ESTABLISHMENT

Detailed techniques of establishing grasses, legumes and woody plants are not attempted in these guidelines. This kind of information is included in SCS Technical Guides and other references that are available in Work Unit Offices.

In urban developments, soils usually encountered for seeding or planting purposes are of the B and C horizons. These soil materials are usually infertile, acid, poor in structure and aggregation, have little or no organic matter and are low in micro-organisms. They are also subject to considerable erosion.

The establishment of plants on such sites is difficult. However, there are certain general principles that apply. These principles are:

- Grade down to flatter and shorter slopes, if possible.

- Spread topsoil when economically and technically feasible.

- Prepare a seedbed or site that will provide soil stability so seed or seedlings can remain in place long enough to grow.

- Fertilize and lime as needed.

- Use adapted species to suit climate, site conditions and purpose of plantings.

- Use proper planting techniques at the proper season.

- Mulch to protect soil and provide a better environment for plant growth.

Grasses and Legumes

Grasses and legumes may be established from seed, seed-bearing hay, plants, sprigs or sod. Seeding is much less expensive than other planting methods. Commonly used methods of seeding in urban areas are - grain drills, cultipackers or corrugated rollers with grass seeding attachments; handoperated cyclone seeders; truck-mounted broadcast seeders; and hydroseeders.

The use of plant crowns, clones, or plugs for propagation is usually the most expensive method of planting. This is due to high costs of plant materials and increased labor required for planting. It is a seldom used method but it may be feasible on some sites.

Sprigging is a method of propagating stolon-type grasses. Most bermuda grasses are in this category. Sod of stolon-type grasses is lifted, chopped or shredded to provide sprigs 6 to 8 inches long. These are set promptly in well prepared moist seedbeds. Caution must be used to prevent drying or heating between lifting and planting.

Sodding is done in three forms: spot, strip, and solid sodding.

Spot sodding is planting small pieces of sod at more or less regular intervals. Grass will grow and fill in blank spaces. It is practiced with grass species that spread rapidly. Sod must be firmed into the seedbed to insure good contact of sod roots with new soil.

Strip sodding is the laying of parallel strips of sod at prescribed intervals. This is often done on slopes. Spaces between strips may be seeded or sprigged to hasten complete ground cover.

Solid sodding, which is the most expensive method of sodding, is complete coverage of an area. This method may be used on critical areas such as around drop inlets, on bottoms of grassed waterways and on steep slopes.

Soil acidity and low fertility are common limiting factors in establishing plant cover in urban areas. Soil tests can identify these conditions and corrective amounts of lime and fertilizer can be applied. In the absence of soil tests, general recommendations used in the local area may suffice for applying these two ingredients to the soil.

Mulching is important in establishing grasses and legumes. Mulch protects the surface from erosion; holds seed, fertilizer and lime in place; helps keep soil temerature more uniform; holds moisture and slows down evaporation. Mulch should be applied uniformly and held in place by proper anchoring. Mulch should not be applied in quantities that will prevent emergence and growth of plants.

Common types of mulch materials are hay, small grain straw, wood chips or wood-based mulches, jute matting, cotton and paper netting, glass fiber netting, plastics and asphalt emulsion.

Anchoring mulch is essential. It should be done immediately after mulch is spread to prevent movement by wind or water. Anchoring may be done by one of several methods depending upon size of area, erosion hazard, steepness of slopes and costs. These methods include the use of (1) tractor-drawn implements such as disk-type machines, cultipackers, sheepsfoot roller or pick chains, (2) hydromulchers combined with asphalt sprays, (3) pegs, staples or twine and (4) by slitting the mulch with a square-pointed spade.

Woody Plants

Seedlings or transplants being planted as bare root stock should only be planted in early spring. Only balled and burlapped will be successful in fall of year plantings.

March 1 - May 15 - Bare-rooted stock
Balled and Burlapped

October 1 - November 20 - Balled and Burlapped

In case of heavy sod or competing vegetation, scalp an area 18 inches to 24 inches clear and plant tree or shrub in center. Dig hole two or three inches deeper than plant root length, plant center hole and work soil in around roots. When plant is set, mulch around plant 1 to 8 inches to control weeds, and hold moisture.

Plant only trees or shrubs that are suited to the soil or site conditions. Local planting guides will supply this information.

## Topsoiling for Grasses and Legumes

Topsoiling is expensive and in most cases is not justified on large areas. Stockpiling existing topsoil from the area being urbanized is much more desirable and less expensive than outright purchase. A study of local soil profile characteristics should be made to determine the need for saving existing topsoil or bringing it in from an outside source. Many subsoils have desirable physical characteristics though they may be acid and low in fertility. Satisfactory stands of grasses and legumes are usually obtained on such subsoils by applying sufficient amounts of fertilizer, lime and mulch.

The use of off-site sources of topsoil may be justified where soil materials are extremely permeable, very fine textured, low in organic matter, poorly aggregated, very shallow and underlain by impervious layers, or where exposed layers are strongly acid, alkaline or salty. Where topsoil is required, it should consist of natural surface soil, friable and loamy in character. It should be capable of producing good stands of grasses, legumes or other kinds of vegetation. It should be free of brush, stumps, litter, objectionable weeds, stones, rocks and contain no toxic substance that may be harmful to plant growth. A pH range of 5.0 to 7.5 is most desirable. Soluble salts should not exceed 500 ppm.

The depth of topsoil to be applied is dependent somewhat on its characteristics and material to be covered. Ordinarily, 3 to 6 inches, after settling, is considered adequate for establishing grasses and legumes. A 6 inch depth of loose soil will settle an inch or two. An important part of topsoiling is to obtain a good bond between the applied soil and the material underneath. The surface, if possible, should be scarified before topsoil is applied. Adequate compaction is also beneficial to a desirable bond between layers. Proper bonding is especially important on sloping lands.

Volume of Topsoil Required for Application to Various Depths

| Depth (Inches) | Cubic Yards Per 1,000 Sq. Ft. | Cubic Yards Per Acre |
|---|---|---|
| 1 | 3.1 | 134 |
| 2 | 6.2 | 269 |
| 3 | 9.3 | 403 |
| 4 | 12.4 | 538 |
| 5 | 15.5 | 672 |
| 6 | 18.6 | 807 |

Slope Stabilization for Establishment of Grasses and Legumes

Cut and fill slopes are created on construction sites or urbanizing areas. These slopes present many erosion hazards and soil stabilization problems. Unless the surface is protected with vegetation or some form of mulch, considerable soil loss will occur from rainfall and flowing runoff water.

Planning slopes, in accordance with data from geologic reports, soil surveys, topographic conditions and the hydrology of the area, will often minimize damage from erosion. These data should contain information on soil types, soil erodibility and important characteristics of the soil profile. Such information should serve as guides in locating best areas for cutting, establishing proper angles of slope and for determining control practices to check slips, slides and erosion.

Climate and rainfall, permeability and runoff, productivity, structure and dispersion characteristics are important factors in surface stability. These factors are closely related to the preparation of seedbeds, liming, fertilizing, seeding and mulching to protect soil from erosion.

Steep slopes make the establishment of vegetation difficult. Best slopes for seeding grasses and legumes, with tractor-drawn equipment are 1:1 or flatter. Slopes that are steeper than 3:1 may require hydroseeders, mechanical mulchers or hand labor. Unstable soils will cause a vegetated slope to slip.

For adequate stabilization it is necessary quite often to supplement a vegetated slope with structural or mechanical practices. These may include retaining walls, protected outlets for water, diversions, berms, terraces, furrows and internal drainage facilities.

Slope limitations and minimum setback requirements are often specified by local authorities to minimize erosion and sediment.

Grassed Waterways or Outlets

Vegetation-lined waterways are used in urban areas to safely carry runoff water to a disposal point. The vegetation serves a dual purpose. It keeps down the speed of flowing water, and it provides a line to protect the waterway from eroding.

In selecting adapted grasses for a waterway lining, those that germinate quickly and grow rapidly are desirable. Early establishment of a complete grass cover is important. The most critical period for a waterway is during grass establishment. Rains may cause rilling of waterway bed and wash out seeds and seedlings. Sod grasses are perferred to bunchgrasses for waterway linings. The dense and uniform sod reduces turbulence of the water. Grass in a waterway should withstand the bedding and beating of flowing water without breaking. A grass should recover its normal growing position after the flow or it may rot in the waterway bed. The grass should also withstand some sedimentaiton. Under some conditions, soil is deposited in the channel and grass should be able to grow up through the sediment. Grasses in a waterway may be established by sprigging or sodding. Sprigging or sodding are more expensive methods of vegetating a waterway, but the control is expedited.

If a new waterway is to be constructed and soil material left after construction is not suited for planting, topsoil should be stockpiled and replaced uniformly over the surface when channel is completed. Mulch or netting over a heavy sedding will help protect the newly graded waterway from splash erosion and excessive runoff. Solid sodding down the center of a new waterway may retard cutting of the waterway bed during the grass establishment period.

Ditch and Channel Bank Seedings

The function of lining a ditch or channel bank is to convey water to the point of disposal as rapidly as possible without damage to grounds by loss of soil or water.

Grasses and legumes are commonly used for stabilizing ditch and channel banks, berms and spoils. The vegetation used for lining banks should be capable of holding soil in place, forming a solid smooth surface, and recovering rapidly from unusually heavy flows that may occur in the ditch or channel.

## 440 MANAGEMENT OF TREE COVERED AREAS FOR RECREATION OR HOME SITE DEVELOPMENT

It is common practice to advertise "Wooded Building Lots". This can be a few scattered trees in an abandoned pasture area or a portion of a dense woodland. The presence of trees on any recreation or home site area will definitely increase the value of the area, if the trees are adapted species, their condition is good, and they are properly located on the area.

One of the first jobs is to determine the type of trees or shrubs that are growing on the tract. With the aid of non-expensive tree and shrub guides, the landowner should identify major species. It is well to locate on a sketch drawn to scale the more important specimens prior to any thoughts of cutting or thinning. Too often areas are bulldozed clear of all vegetation and then costly replanting is needed.

The problem in development of many sites is to retain proper trees for shade, and still establish grass cover between trees. Size of the area, soils, topography, erosion hazard, and the owner's desire must all be considered in tree retention.

Criteria to use in selecting trees to retain in recreation or home site developments:

- Esthetic values

  Consider fall color of foliage, flowering habits, bark and crown characteristics, type of fruit, view from building site, and the screening value of the trees.

- Health of tree

  Retention of unhealthy trees will create a definite hazard within the area, and lead to expensive removal later. Outside the danger zone of buildings and play areas, the retention of a few den trees should be encouraged.

- Size and age

  Old trees do not always adapt well to changes in environment. Young to medium aged trees are most desirable. Large trees require a lot of space, and generally only 10 to 15 trees of a diameter of 10 inches or over can be retained per acre. Some species are rather short-lived and are poor risk trees for long-time use. (Silver and Red Maple, Chinese elm, Lombardy Poplar, etc.)

- Wind firmness

  It is very important that deeper rooted trees be favored for saving. This will result in wind firmness and a much improved chance to have grass under the trees.

  Species inclined toward development of deeper roots are: red, bur and white oaks, sugar maple, hickory, black walnut, etc.

  Keep in mind that soil types may require shallow root development regardless of species.

- Wildlife values

  Oaks, hickories, dogwood, redbud and persimmon all have a high value for wildlife food. Retention of these species tends to bring song birds and other types of wildlife near heavy use areas.

- Comfort Index

  Trees give off moisture and oxygen from their leaves. This tends to cool high temperatures and reduce air pollution. Hardwoods do a better job in this respect than the evergreen species.

- Growth space

  When selecting trees to retain, figure on their future growth in respect to location of electric and telephone lines, water and sewer lines and driveways.

Criteria to Use in Clearing for Recreation or Home Sites:

The number of desirable trees for retention on an area will not be great, so it is important they be marked clearly for all workmen to see and avoid. Bright colored plastic ribbons, string or yarn tied around trees will serve well to indicate trees to be retained.

- When clearing out undesirable trees or shrubs do not use the bulldozer.

  Cut trees to be removed flush to the ground line by using an ax and chain saw. If cutting is followed closely with a good mowing program, stumps will soon rot away. Some landscape companies and nurseries have stump removal machines that grind stumps away 5 or 6 inches beneath ground level. The depression can then be filled with topsoil and be ready for seeding.

Bulldozing out unwanted trees usually results in serious damage to roots and tops of trees being retained. Topsoil and organic matter are often pushed off with the trees being removed.

- Woody material being removed should not be burned adjacent to retained trees.

  Safe burning areas must be out beyond the farthest extending limbs of live trees to avoid root and top damage. Cut trunks and heavy limbs into fireplace wood, and place brush into loose brush piles beyond proposed mowing areas.

- Damaged limbs in clearing area, dead and dying limbs, and lower limbs which will interfere with mowing should be removed at time of completing clearing operations.

  Any limbs removed from trees should be cut in such a manner that the final cut is made flush with the tree trunk. All scars resulting form this type of tree pruning should be covered immediately with tree wound dressing.

- Where grass is to be seeded in tree thinned area, only light discing should be performed in preparing a seedbed.

  Heavy discing or plowing will seriously damage feeder roots of desirable retention trees and shrubs.

- Earth and building materials should not be piled around the good trees.

  Graders have a way of piling earth against tree butts and then leaving it there on the theory that the finegrading, by hand, will be done soon. It seldom is, and the piled material can be fatal to a tree after just a few weeks. Where permanent fill is required around a valuable tree, drainage tile opening into a tree well should be used.

- On larger tracts it is often desirable to leave part of the trees and shrubs in a wild type of growth.

  Example - steep escarpment areas, a strip for screen along boundary or a divider between two heavy use areas, and a screen to hide unsightly vistas.

- When thinning out native trees or shrubs to provide open space for intensive use of building sites, it pays to be conservative.

  Small thinned or cleared areas will serve for a few years, and additional open space can be added gradually as needed. Trees become acclimated better when the thinning process is slow and gradual.

- After clearing progresses to the point where all remaining trees and shrubs should be retained, the proper maintenance of these plants will be very important.

## 500 MAINTENANCE - SOIL AND WATER MANAGEMENT SYSTEMS

### 510 MAINTENANCE - ENGINEERING

All structural measures for control of erosion, sediment and water disposal must have timely maintenance if the measures are to endure and perform their function. All structures should be inspected at least simi-annually and after each heavy rain.

A comprehensive program should be outlined for use of those who have maintenance responsibility. Maintenance items should include but not be limited to those shown for each of the following measures.

Lined Channels

Check for: cracking, spalling, deterioration from freezing, salt or chemicals, plugging of weep holes, operation of automatic drainage gates, condition of safety fences, channel obstructions, scour at inlet and outlet.

Cracks should be sealed, protective coatings applied when needed and modifications, riprap or repairs made where and when necessary.

Channels, Earth

Check for: points of scour or bank failure and deposition, rubbish or channel obstructions, rodent holes, excessive wear from play, traffic or settling.

Remove deposition and undesirable plant growth. Repair damages from scour, rodents and loss of freeboard.

Embankments

Check fills for cracks, damage from wave action, rodents and undesirable vegetation growth as well as obstructions to principal and emergency spillways. Check gates, trash racks, metalwork, anchors, conduits and appurtenances for damage from corrosion, ice and debris.

Filling of scour holes, modification, riprap, repair of damaged vegetative cover, obstruction removal should be on a timely basis.

Valves and gates should be cleaned, lubricated and operated through their full range.

Unauthorized modifications, tampering or vandalism must be remedied or controlled.

## 520 MAINTENANCE - VEGETATIVE

Maintaining vegetation for soil protection or other uses is needed to keep it functioning. Proper maintenance defers or prevents impairment of plant cover. It is usually less costly to carry on a maintenance program than it is to make repairs after an extended period of neglect.

Maintenance should occur on a regular basis, consistent with favorable plant growth, soil and climatic conditions. This involves regular seasonal work for mowing, fertilizing, liming, watering, pruning, fire controls, weed and pest control, re-seeding and timely repairs. It also requires prompt removal of debris, protection of vegetation from unintended uses or traffic and special attention to critical areas. Well-maintained vegetation provides a comfortable margin of reserve that will carry through emergencies. A preventive maintenance program anticipates requirements and accomplishes work when it can be done with least effort and expense.

The degree of preventive maintenance depends upon the category of the vegetation and land; i.e., improved, semi-improved and unimproved grounds. More intensive maintenance operations occur on improved grounds and less intensive on unimproved grounds. Regardless of the category, vegetative cover requires a certain degree of management or the desired function of the vegetation will be defeated.

Mowing is a recurring practice and its intensity depends upon the function of the ground cover. On improved areas, such as lawns, certain recreation fields and picnic areas, mowing will be frequent. On semi-improved areas, mowing will be less frequent. On unimproved areas, mowing may occur once or twice a year as required to prevent erosion and eliminate fire hazards.

The application of fertilizer will follow a like pattern. On improved areas, fertilizer amounts should be in sufficient quantities to keep cover healthy and vigorous without over-stimulation of growth. On semi-improved grounds, the rate of fertilizer application is usually about ½ the rate applied on improved areas. Unimproved areas should receive limited fertilizer applications as required to produce enough growth to prevent undue erosion.

Lime should be applied to maintain the desired level of soil reaction. On improved grounds, amounts of lime may be applied to maintain the optimum pH range. On semi-improved and unimproved areas, the pH may be proportionately higher or lower than optimum.

Weeds and brush frequently invade grass cover as a direct result of inadequate maintenance. Amounts of weeds or brush that can be tolerated in any protective planting depends upon the land category and its intended use. On improved areas little or no weeds or undesirable brush should be tolerated. This tolerance may become proportionately greater as land category declines. Drainageways are subject to rapid infestation of weeds and woody plants. These should be eradicated or cut back since they often reduce drainageway efficiency. Control of weeds or brush is accomplished by using approved herbicides, mechanical methods, soil sterilants and, perhaps roguing.

Pest and disease control requirements are usually more intensive on improved areas. Most insects, such as grubs, crickets, chinch bugs, grasshoppers, army worms, beetles and ants, feed on grass roots, stems and leaves and may cause considerable damage in a short space of time if not controlled early. Rodents, such as field mice, ground squirrels, gophers and moles, may damage vegetation and create hazards by burrowing the throwing up mounds on earthen structures. Insects and rodents should be kept under reasonable control.

Diseases of herbaceous and woody plants are usually of minor importance where adapted species have been used and reasonably good management is practiced. Trees that have been destroyed by disease or seriously damaged by insects should be removed. Removal of such trees is essential if the diseases and insect infestations are likely to spread to other plants.

Dry vegetation constitutes a fire hazard. The taller the vegetation, the greater the hazard. Herbaceous vegetation on improved grounds may be less subject to serious fire since it is kept well mowed and probably well watered. Tree and shrub areas on improved ground also undergo fairly intensive management. Debris, such as fallen trees and branches, is usually removed without undue delay and litter is occasionally cleared away. These practices reduce fire hazards considerably. On unimproved grounds, vegetation is usually allowed to grow tall. Mowing and removing residue may help prevent fires in such areas. In general vegetative fires in the Northeast Region are not critical. Judicious care, consistent with land category and purpose of vegetation will usually help prevent fires.

APPENDIX

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE _____ COUNTY PLAN COMMISSION

and the

THE _____ COUNTY SOIL AND WATER CONSERVATION DISTRICT
STATE OF INDIANA

This Memorandum of Understanding is between the _____ County Plan Commission, State of Indiana, hereinafter called the Commission and the _____ County Soil and Water Conservation District, herinafter called the District. It is effective on the date it is signed by the authorized officials of the Commission and the District.

## STATEMENT OF PURPOSE

The District has been organized pursuant to the Soil Conservation District laws of Indiana as a governmental subdivision of the State. It is prepared to exercise within its boundaries public powers as authorized by that law.

The District has adopted a program outlining in general its soil, water, and related resource conservation and use objectives. The District is concerned with the conservation, use and development of soil, water, and related resources to provide for the greatest enduring benefit to the individual, the community, and the District.

The Commission is authorized by State Law and by County and Town Board Ordinances.

The Commission is concerned with the orderly growth of _____ County and to make or revise plans for various wise land uses in the most efficient, effective and beneficial manner. The Commission endeavors to control the use of land and buildings; to lessen congestion in the streets; to secure safety from fire, panic and other dangers; to promote health and general welfare; to provide adequate light and air; to prevent overcrowing of the land; to facilitate the adequate provisions of transportation, schools, parks and other public requirements; to make and carry out land use plans with reasonable considerations that encourage the most appropriate use of land throughout said county in accordance with the comprehensive plan.

## BASIC PLANNING PRINCIPLES

The Commission and the District recognize that the same land use planning steps are needed, whether dealing with an individual field, farm, community, town or state. The same kinds of basic resource data, and the same steps of inventory analysis, comparison of alternatives, and decision making are required.

The Commission and the District recognize that the more people become involved in planning objectives for the land use planning area, inventorying the resource, planning development needs, and setting goals, the more they will accept the responsibilities for accomplishing the goals. The joint challenge is to create an awareness of future problems and opportunities, create a desire to be involved in the planning process, and provide a means by which the people can constructively express their opinions.

The Commission and the District recognize the indispensable base of sustained economic growth is the proper care of land, water, and related resources.

The Commission and the District recognize that the husbandry of physical resources without relation to human goals is pointless; that planning must provide for the physical, social, and economic welfare of all people in the community - rural and urban - if it is to be accepted and carried out. Further, the Commission and the District recognize that planning is a continuous process that must be done with people - not for them. Local people and their leaders are the key to success.

These principles lead to the desire for the Commission and the District to develop and set forth an enduring basis for cooperation and mutual assistance.

## WHAT THE COMMISSION WILL DO

1. The Commission will seek resource planning and assistance as available from the District. This includes soils maps, soil survey information and interpretations, conservation needs information, and potentials for local water resource development.

2. The Commission will seek the active participation and assistance of the District in both local resource planning and implementation of plans.

3. The Commission will inform real estate developers and others contemplating changes of land use, of the availability of soil survey information and interpretations from the District.

4. The Commission will make available to the District information related to the District's program.

5. The Commission will request the District to review subdivision plans for satisfactorily overcoming soil limitations, adequacy of planned water disposal systems and erosion controls measures.

## WHAT THE DISTRICT WILL DO

1. The District will help create public interest in and support of the local comprehensive plan.

2. The District will help the Commission to understand the basic planning principles relating to local resource conservation needs and development.

3. The District will seek to actively participate with the Commission in arriving at wise local natural resource conservation use and development plans.

4. The District will provide the local Commission all available data and information related local resource planning and will assist the Commission to obtain needed data and information. This includes comprehensive soil survey information and interpretations also conservation needs information.

5. The District will work with the Commission in order to determine effective ways to develop the local resources of the area being studied for the greatest sustained benefit to the county, town, or area.

6. The District will assist the Commission to determine the mutual compatibility of the Commission's comprehensive plan with the District's plan.

7. The District will, upon request by the Commission, provide available consultative assistance related to local development of natural resources.

8. The District will, upon written request by the Commission, provide, as available, standard soil survey information and interpretations, for areas on which a change of land use is being studied.

9. The District will review subdivision plans for their adequacy in (a) overcoming soil limitations, (b) adequately solving the water management problems, and (c) satisfactorily providing for erosion control.

JOINTLY DO OR MUTUALLY AGREE

1. The District and the Commission will work jointly in the preparation of subdivision regulations that will utilize the new soil survey and interpretations in setting standards for land development including (a) restricting use of land with severe limitations, (b) overcoming soil limitations, (c) solving water management and erosion control problems, (d) meeting together jointly at least once each year to review past accomplishments and plan for the coming year.

THE _____ COUNTY SOIL AND WATER CONSERVATION DISTRICT

BY: _____
Chairman

DATE: _____

THE _____ COUNTY PLAN COMMISSION

BY: _____
Title _____

DATE: _____

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